CHRONIC MALNUTRITION IN RURAL ZIMBABWE

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by

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DEDICATION

To the families of Buhera District, Zimbabwe, whose commitment and collaboration, made this study possible.

Ndatenda

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Nutrition
enhances potential for future development

Declaration of originality

I hereby declare that this thesis has been composed by me and that all work presented in this thesis is my own, unless specifically stated otherwise.

Patricia J. Mucavele **2003**

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ABSTRACT

Chronic energy malnutrition remains the major silent global nutritional challenge for the future. This thesis investigates specific factors which may have contributed to its unabated persistence. A critique of the literature concludes that nomenclature, the complexity and unspecific nature of multi-factorial chronic malnutrition problems, narrowness of medical physiological based conceptual models to identify the origins of nutritional risk, and the technical difficulties associated with the accurate assessment and monitoring of nutrition status amongst the free-living have contributed to the limited progress in abating chronic energy malnutrition.

To illustrate the dimensions of the above problem the prevalence, severity, seasonality and determinants of chronic energy malnutrition within and between subsistent agricultural households residing in a drought prone, food deficit area of Zimbabwe are investigated. A comprehensive longitudinal food, health and anthropometric survey of 354 households was conducted over a 15 month period and has been analysed. To capture both the seasonal dynamics of the nutrition situation and intra-household nutritional status, all household members were measured. Anthropometric indices were used as proxies of child and adult nutritional status. To identify the main risks and determinants of nutrition security a set of simple indicators used as proxies for dietary intake, health status, care and household welfare were estimated and equated with anthropometric status.

Simultaneous analysis of adult and child anthropometry unveiled a paradoxical situation with the co-existence of high prevalence of chronic under-nourishment amongst children with high rates of adult female over-nourishment. Over a third of the children were diagnosed as stunted, (height for age <-2SD) and quarter were estimated to be underweight (weight for age <-2SD). Concurrently, over a fifth of the adult female population were classified as overweight (BMI 25-29.99) a further 10% depending on the season were diagnosed as obese (BMI >30). Contrarily, a quarter of the male population were diagnosed as chronic energy deficient CED (BMI <18.5). Male over-nourishment was virtually non-existent. Combining the above results with

low rates of child wasting <10%, the Buhera population is diagnosed as severely chronically malnourished. The study attributes the intra and inter household differences in nutritional status to physiological, diet, infection, socio-economic, cultural and environmental factors.

The seasonal variation in nutritional status was uncharacteristic. Optimal adult nutritional status was observed in March at the end of the *pre-harvest period.* Modest seasonal oscillations in adult body weight equivalent to an absolute change of 4-5% were observed. Seasonal fluctuations in child growth rates were detected, a lagged association was found between significant *pre-harvest* weight gains and the following *post-harvest* rate of height velocity. Self-reported illness was associated with seasonal weight loss.

The existence of both extremes of the chronic energy malnutrition spectrum within and between households suggests considerable heterogeneity in biological response to prevailing food insecure and poor environmental conditions in Buhera. The low ratio of CED:obesity observed amongst women provides evidence that over-nourishment previously associated with affluent societies is becoming the burden of the rural poor. These two findings present a dual challenge when developing policies and programmes to alleviate chronic malnutrition.

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Abbreviations and acronyms

ACC/SCN	Administrative Committee on Coordination/ Sub-Committee on Nutrition
AGRITEX	Agriculture Extension Service
AIDS	acquired immunodeficiency syndrome
ANDI	African Nutrition Database Initiative
ARI	Acute Respiratory Infection - short-term infections of the lung characterised by coughing or difficulty breathing
BMI	Body Mass Index - (weight/height^2) an index of protein and fat stores
BMIZ	Body mass index for age z-score
CA	Communal Area
CI	Confidence interval
CDC	Centers for Disease Control
CED	Chronic energy deficiency - a steady state at which a person is in an energy balance although at a cost either in terms of increased risk to health or as an impairment of functions and health (James *et al.* 1988)
CMR	Crude Mortality Rate
CPI	composite price index
CSO	Central Statistics Office, the Zimbabwean government department responsible for collating statistics
DDS	Dietary Diversity Score
DES	Dietary Energy Supply
DHS	Demographic Health Survey
DSW	Department of Social Welfare, the Zimbabwean government department responsible for adminstering drought relief, pensions, and other forms of welfare.
DTP	Diphtheria, Tetanus and Polio
EPI	Expanded Programme of Immunisation
ESAP	Economic Structural Adjustment Programme, a package of policy reforms implemented by the Zimbabwean government since 1991.
FAO	Food and Agricultural Organisation of the United Nations
FEWS	Famine Early Warning System, a project funded by the U.S. Agency for International Development that attempts to warn the international community of impending food shortages
FSAU	Food Security Assessment Unit
FVS	Food Variety Score
GDP	gross domestic product
GIEWS	Global Information and Early Warning System, FAO warning system
GIS	Geographical Information System, used for the input, storage, manipulation, analysis and output of digital maps and associated information.
GMB	Grain Marketing Board, a parastatal or quasi-governmental organisation that formerly controlled strategic grain reserves, grain

	movement, and prices.
GNP	gross national product
GOZ	Government of Zimbabwe
GPS	Global Positioning System, a system of satellites and receivers that can be used to locate features on the Earth's surface with a high degree of accuracy.
HA	Height for age
HAZ	Height for age z-score
HH	Household
HDI	Human Development Index
IACS	Index of Agro-Climatic Seasonality
IBRD	International Bank for Reconstruction and Development
ICN	International Conference on Nutrition
IDECG	International Dietary Energy Consultancy Group
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMFSZ	Integrated Model of the Food System in a Region of Zimbabwe
IMR	Infant Morality Rate
INCAP	Institute of Nutrition of Central America and Panama
INN	National Institute of Nutrition, Rome
IUGR	intra-uterine growth retardation
LBW	low birth weight
MCH	Maternal and Child Health
MOA	Ministry of Agriculture
MOH	Ministry of Health
MPSLSW	Ministry of Public Service, Labour and Social Welfare
MUAC	Mid Upper Arm Circumference
NCHS	National Center for Health Statistics
NGO	Non Governmental Organisation
NHIS	National Health Information System, run by the Zimbabwean Ministry of Health
OR	Odds risk ratio
ORT	Oral Rehydration Therapy
PCD	Partnership for Child Development
PEM	protein-energy malnutrition
PPV	Positive predictive value
RDA	Recommended Daily Allowance
RR	Relative risk ratio
SADC	the Southern African Development Community, a regional grouping of 14 countries
SD	standard deviation
SES	socio-economic status
U5MR	Under Five's Mortality Rate
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNU	United Nations University

VIDCO	Village Development Committee, the lowest tier of government within Zimbabwe's communal lands. The VIDCO is both a political body and a geographic entity comprising around one thousand people.
WA	Weight for age
WADCO	Ward Development Committee
WAZ	Weight for age z-score
WFC	World Food Conference
WFP	World Food Programme
WFS	World Food Summit
WH	Weight for height
WHO	World Health Organisation
WHZ	Weight for height z-score
WSC	World Summit for Children
WTO	World Trade Organisation

Translations of Shona or Zimbabwean words

Dambo -	an area of wetter drainage, often artificially created by damming a water-course for the purposes of grazing cattle (Shona).
Kraal -	Zimbabwean word for village or small rural settlement.
Lobola -	the practice of a prospective husband paying the family of his bride an agreed number of cattle in exchange for permission to marry (Shona).
Mhunga -	pearl millet (Shona).
Rapoko -	finger millet (Shona).
Sadza -	a porridge, usually made from maize meal, that forms the staple of the Zimbabwean diet (Shona).

CHAPTER 1 INTRODUCTION

1.1 General problem statement

Dr Nevin Scrimshaw was the 1991 laureate of the World Food Prize, the foremost international award recognising outstanding individual contribution to the improvement of quality, quantity, or availability of food in the world. When receiving this award Dr. Scrimshaw stated:

"Chronic malnutrition continues to remain the silent major global nutritional challenge for the future" (Scrimshaw, 1994).

This sentiment has been reiterated many times during the last decade by individual nutritionists, agriculturists, economists and international organisations concerned with food security, nutrition and health (ICN, 1992; World Bank, 1997; UNICEF, 1998; ACC/SCN, 1999; Underwood 2001).

The problem of persistent high levels of chronic malnutrition is not new. The nature, extent and severity of chronic malnutrition and the implications for human and national development have been studied extensively for the last half-century. The sphere of protein-energy malnutrition (PEM), its aetiology and pathogenesis were first recognised early in the twentieth century through the pioneering work of Williams (1933, 1935) who described the symptoms of kwashiorkor. Subsequently, others including Waterlow (1948), Trowell and Dean (1952), Jelliffe (1959) and Whitehead (1969) conducted extensive metabolic and biochemical studies. However, it has only been in the recent decades that there has been a realistic notion of both the spectrum of disability and the vast global dimensions of those affected by chronic malnutrition.

Sophisticated communication systems keep the international community and the layperson alike informed of the occurrences of acute malnutrition worldwide. The graphic pictures and heart-rendering descriptions of starving children and wasted adults are periodically shown in the media to create awareness of the need for financial and humanitarian assistance. A high prevalence of acute malnutrition is associated with rapid increase in mortality. However, these acute forms of undernutrition are insignificant compared to the costs associated with chronic mild and moderate malnutrition. Whether measured in terms of the number of people affected, the proportion of humanitarian assistance provided, or the subsequent number of attributed disabilities, illnesses and deaths, the cost of chronic malnutrition is extremely high.

It is indisputable that famines and mass starvation are tragic occurrences. However, it is chronic undernutrition which remains the relatively silent problem that is responsible for increased mortality rates, higher incidence of morbidity and reduced capacity to learn, work and reproduce. The accumulated effect of chronic undernutrition has a negative impact on the social and economic development of the individual and the nation, yet it is less well-publicised (World Bank, 1993; Scrimshaw 1994; UNICEF, 1998). Only 1-2% of the world's children exhibit visible signs of acute malnutrition, such as marasmus, or kwashiorkor (de Onís *et al.*, 1993). To use an analogy, the severely malnourished represent only 'the tip of the iceberg' of PEM. The great submerged mass of individuals who suffer from mild to moderate weight and height deficits have remained marginalised in the competition for scarce resources.

The phenomenal suffering and functional implications associated with mild and moderate chronic energy malnutrition have only been recognised in the last three decades. Any deterioration in nutritional status carries with it an increased risk of mortality. Thus, a severely malnourished child is 11 times more likely to die than a well-nourished child. A moderately malnourished child is 3 times more at risk of death, and a mildly malnourished child is twice as likely to die compared to a well-nourished child. Since, the volume of malnutrition globally is in the mild and moderate category and 45-83% of all malnutrition-related deaths occur to children in these categories, it is imperative that attention is focused on this group to improve mortality rates (Pelletier, 1993; Brundtland, 2000).

Throughout the 1980's the debt crisis, structural adjustment, and the environment dominated policy debates (Maxwell, 1998). In the beginning of the 1990s hunger, food and nutrition moved to the forefront of policy discussions. On three occasions, the issue of malnutrition reached global recognition during the 1990s. In the World Summit for Children (WSC) in New York, 1990, at the International Conference on Nutrition (ICN) in Rome, 1992 and during the World Food Summit (WFS) in Rome in 1996, food security and malnutrition were the main focus. The International Decade for Food and Nutrition has given nutritional issues a high profile and global recognition of the problem of malnutrition. A set of declarations, goals, targets, general and specific principles have been stated and internationally ratified, all aiming to reduce and eventually eradicate chronic malnutrition (Pellett, 1993; UNU, 2000). This has set the public nutrition agenda for the 21st century.

Many factors have contributed to the limited progress in abating both overt and hidden malnutrition. Environmental catastrophes and wars are exacerbating factors but they are rarely the primarily cause of hunger and malnutrition. The basic causes are rooted in and stem from social, economic and political policies (Banerji, 1988; Thomas *et al*., 1989). Government investment and policy ultimately prescribes the degree to which the fundamental human right to consume an adequate diet is achieved; determining who gets, what, when, where and how, and who controls these processes (Draper and Dowler, 1999). Political, legal and cultural factors often destroy or at best drastically constrain the anticipated impact of direct or indirect food, nutrition and health interventions. For example, the adverse impacts of many recent macro-economic adjustment programmes on vulnerable groups, highlighted by UNICEF, has resulted in a global awareness of the need for *'adjustment with a human face'* (Cornia *et al*., 1987; Sahn, 1995). Structural programmes enforced by the international finance agencies, the International Monetary Fund (IMF) and the World Bank (IBRD), to reduce government spending and improve balance of payments were re-designed with potential nutritional effects in mind; while programmes already in operation, are having 'compensatory programmes' tacked on to buffer the poor from initial detrimental impacts on welfare (Gillespie, 1992; Geissler, 1999). Overcoming malnutrition requires implementation of policies that facilitate food production, reduce the burden of poverty and increase social equity, improve nutrition and health simultaneously (Brown University Faculty, 1990; Maxwell, 1998).

Government policy apart, those working within the sphere of nutrition have a major role to play in the alleviating the immediate and underlying causes of malnutrition. Multi-disciplinary research has contributed to a more in-depth understanding and appreciation of the multi-factorial complex nature of malnutrition particularly for countries in nutrition transition (Valyasevi and Dhanamitta, 1995). It is internationally recognised that for nutrition to improve, many factors are necessary and no one formula can be prescribed (UNICEF, 1998). The lack of appreciation of the complexity of the nutrition problems, their unspecific nature, the theoretical and technical difficulties associated with the measurement of nutrition and the lack of establishing cause and effect during analysis have all contributed to many nutrition interventions in the past having had limited and or unintended impact (McLaren, 1974; Olson, 1981, Basta, 1989). Approaches used to assess, analyse and act to alleviate malnutrition remain areas of contentious debate amongst the various professions involved in its reduction and eventual eradication (Osmani, 1992).

It is evident that the problem of chronic malnutrition is not the sole domain of the nutritionist or nutritional sciences (Pinstrup-Andersen, 1993). It is however, obvious that the nutrition profession and discipline has a crucial role to play in the assessment, analysis and the advocation of policies and programmes (Rogers and Schlossman, 1997). There is need to critically evaluate the theoretical assumptions and technical approaches used to assess and monitor nutritional security and explore different ways in which the complexity of malnutrition can be accurately measured, effectively analysed and appropriately alleviated (Babu, 2001).

1.2 Domain of the study

The central argument of this thesis is that the identification, location, quantification, and explanation of who is chronically malnourished have been hampered by the sole use of two traditional nutrition indicators. It is postulated that household calorie adequacy and pre-school child anthropometry provide limited insight into prevalence, severity and multi-factorial nature of the causes of chronic malnutrition within a rural community. This argument pivots on a series of inferences, which have been established through multi-disciplinary research undertaken during the past two decades, which has focused on the measurement, and determinants of chronic malnutrition (Kennedy and Haddad, 1992).

The first inference states that, *"food availability at the national level does not ensure food security at the household level"*. Until recently there had been a tendency to equate hunger with malnutrition and food availability with nutrition (Alderman and Garcia, 1994). Dietary energy supply (DES) expressed as daily calories *per capita* or household calorie adequacy is still extensively used as a measure of undernutrition, (ICN, 1992). In 1974 at the World Food Conference, the world was in a 'food crisis' marked by food shortages and rising grain prices. The conference agenda focused on global and national level food availability as the most immediate food and nutrition problem (National Research Council, 1977; FAO, 1996).

The analysis of hunger and malnutrition in international policy circles has largely centred on Malthusian or neo-Malthusian approaches, these postulate that hunger, malnutrition and ultimately starvation result from a decline in aggregate food availability (Malthus, 1798). The key flaw in this approach is the assumption that as long as food production grows as fast as the population, malnutrition will not be a problem (Chattopadhyay, 2000). However, despite global increases in food availability, which has kept pace with population growth over the last two decades, there has not been a significant decrease in child malnutrition rates worldwide. Hadadd, *et al.*, (1997) have shown that the correlation between child undernutrition (low weight-for-age) and aggregate food availability on a *per capita* basis is small and insignificant for 37 developing countries (-0.0087). Malthusian mathematics is unable to explain the causal mechanisms of how hunger and malnutrition should exist in the midst of plenty (Sen, 1982; de Waal, 1989; Devereux, 1993).

The lack of correlation between energy availability, consumption and malnutrition has led economists and nutritionists to focus on other possible influencing factors. Sen's (1982) economic theory of entitlement evolving from his studies on the causation of hunger illustrated that the traditional analysis of famines focusing on food supply was fundamentally defective. Sen's analysis demonstrated that the populations' access to income (ownership of assets or capacity to exchange labour for goods) determined the capacity to cope and survive (Sen, 1977). This theory is internationally recognised and has been applied through the operational definition of food security combining elements of food availability with food access (Maxwell and Frankenberger, 1992).

The second deduction states that, *"household level food security does not ensure individual level nutrition security"*. Cultural and behavioural patterns of society directly influence the intra-household allocation of resources (Taylor, 1978). Household decision making and behaviour can mediate the impact of nutrition policies and programmes. A large body of literature has shown that the distribution of food, health and care within the household can determine which and how many household members are malnourished (Sen, 1984; Harriss, 1986; Haddad and Kanbur, 1990, 1992; Smith and Haddad, 2000).

This inference suggests intra-household analysis of nutritional status can illuminate the impact that programmes and policies have on the intended beneficiaries within the household (Haddad *et al.*, 1997). Presently, only pre-school child anthropometry is routinely used to target policies and programmes, since it is commonly the only source of nutrition data regularly collected with national coverage. The use of pre-school anthropometry, assumes firstly, that anthropometry is synonymous with nutrition security, secondly that the anthropometric status of pre-schooler children is an appropriate and sensitive index for the nutritional security of all household members and thirdly that seasonal changes in child anthropometry reflect the seasonal changes in the anthropometric status of all household members. Fourthly, the causative factors which are statistically associated with child anthropometric status are similar to those associated with older household members. However, the wider application of the majority of these assumptions have had limited verification. Given the importance of infectious diseases and weaning patterns that are irrelevant to other age groups, the use of pre-school anthropometry as an indicator of population and household nutritional status seems questionable (Kelly, 1992; DeRose *et al.*, 1998).

The third proposition states that, *"adequate food security at the individual level does not necessarily translate into nutrition security"*. Hunger and malnutrition are not synonymous; nutrition is more than food. The assumption that PEM has a simple aetiology has been shown to be erroneous; there has been a gradual recognition since 1970s that malnutrition is an ecologic phenomenon (Craviotio, 1970). Health status, care and a healthy environment are equally necessary conditions for nutrition. Although an adequate dietary intake is a prerequisite it is not the only determining factor of nutritional status. Rather the utilisation of energy and nutrients at the cellular level determines nutrition outcome, a process that can be mediated by many factors particularly an individual's health status (Gopalan, 1992). The 'malnutrition-infection' complex also known as the 'nutrition-infection' nexus is recognised as a powerful determinant of nutritional status. The cyclical nature of diet and disease has been well documented (Scrimshaw *et al.*, 1968). The review by Tomkins and Watson (1989) illustrated how many studies have shown independent and additive effects of ill-health on adult and child anthropometric status. This inference provides an insight into the multi-dimensional nature of nutrition security and the need to estimate access to food, health, care, environmental sanitation and potable water when determining nutritional status (UNICEF, 1998). It also explains why increases in household income and consumption are often not associated with a significant decrease in pre-school malnourishment (Garcia and Alderman, 1989; von Braun and Pandya-Lorch, 1992).

The complexity of conceptual issues involved in establishing the nature of chronic malnutrition are captured by the above three inferences and as such represent the domain of this study. It is apparent from the above synopsis that food security or calorie adequacy although an essential element is not the only factor involved in ensuring nutrition security. It is also evident that the sole dependency of pre-school child anthropometry as an index of household nutritional status could lead to either the misidentification of the most vulnerable households or to inappropriate programmes and policies. This thesis explores these issues in-depth and examines some of the theoretical assumptions and technical approaches used to monitor nutritional security.

1.3 The scope study

This study focuses on the nutritional status of the communal land sector in Zimbabwe. The case for specifically concentrating on a rural subsistent agricultural community within Africa hardly needs justifying. From all perspectives, prevalence rates of chronic malnutrition, economical, developmentally and human rights, there is a strong case to study the nutritional status of the rural poor in Africa.

Sub-Saharan Africa is cited as being the most vulnerable region in terms of food insecurity and is second to Asia in terms of absolute and relative levels of malnutrition. One in two people in Southern Africa are food insecure, and one in four pre-school children are malnourished. The 3rd and 4th World Nutrition Situation Reports, estimated that in 1995 the overall prevalence of stunting in sub-Saharan Africa was 39.4%, the second highest region in the world after Asia. Trend analysis for the period 1980-1995 revealed that the proportion of pre-school children chronically malnourished had declined significantly in all regions of the world except sub-Saharan Africa where the prevalence of stunting had increased 0.13 percentage points per year. More than 8.2 million African children are underweight in the year 2000 compared to a decade ago. The total number of malnourished children is projected to increase further due to population growth (ACC/SCN, 1997; 2000).

Cross-sectional and longitudinal analyses of prevalence rates of child malnutrition between and within countries in the sub-Saharan region show substantial variation. The large variability can be partially explained by the various stages of demographic, epidemiological, economic and nutritional transition being experienced and degree of stability within each country. Sub-Saharan Africa is a region of tremendous contrasts made up of 42 countries[1] which vary immensely in size, population, *per capita* income, gross domestic product (GDP), life expectancy, literacy, education enrolment, human development index ranking, daily *per capita* kilocalories consumption, infant, child and maternal morality rates, low birth rate, provision of potable water and sanitation and child malnutrition (underweight, stunting, wasting) rates (WHO, 1996).

Zimbabwe was selected as an appropriate country within Sub-Saharan Africa to carry out a study on persistent chronic malnutrition as recent empirical research had highlighted a number of the paradoxes related to the inferences described above, viz.: i) substantial reduction in mortality rates despite successive droughts, economic recession and the imposition of economic stabilisation measures; ii) overall adequacy of food supply at the national level in non drought years and concurrent static, and in some cases increases in levels of chronic malnutrition amongst pre-school children (Chivso and Jayne, 1991*a*, 1991*b*; Christensen and Stack, 1992, 1994).

Zimbabwe is located in Southern Africa, a landlocked country bordered by Zambia and Malawi in the North, Mozambique in the East, South Africa in the South and Botswana in the West. It stretches from 15-22 degrees south latitude and from 26-34 degrees east longitude and covers 390,000 square kilometres in area. Although Zimbabwe lies within the tropics, one-fifth of the terrain is over 1,200 m above sea level and three-fifths are between 600 m and 1,200 m so that, only the low-lying Zambezi and Limpopo valleys which demarcate the north and south boundaries of Zimbabwe, experience tropical conditions (Muir, 1994).

In general the topography, soils and climate of Zimbabwe are unfavourable for intensive agricultural production, typifying many Sub-Saharan Africa countries. More than 75% of the country is subject to conditions that make dry land production a risky venture.

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[1] *Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central Africa Republic, Chad, Comoros, Congo, Côte d' Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zaire, Zambia and Zimbabwe.*

However, agriculture dominates the Zimbabwean economy despite the fact that its contribution to Gross National Product (GNP) is generally less than 20%. Agriculture provides an income to approximately 75% of the 10 million population; of these 55% are women. Manufacturing is dependent on agriculture as a source of raw materials, 70% of all consumer expenditure is on products derived directly from agriculture. These strong inter-linkages mean that a poor agricultural season has serious implications for the entire economy. This is reflected in national growth rates and private consumption; economic growth closely mirrors annual rainfall variation (Muir, 1994).

At the time of the study Zimbabwe was categorised as a middle-income country with a medium Human Development Index (HDI) by United Nations Development Programme (UNDP, 1995). However, as stated above, comparative analyses of various development indicators such as GDP, literacy, infant, child and maternal mortality and malnutrition rates, suggest a number of anomalies. This emerging divergence between death rates and quality of life as reflected by nutrition levels is indicative of, on the one hand, rapid expansion and reorientation of the primary health care system and, on the other, little change in socio-economic conditions for the majority of the population (Loewenson *et al.*, 1991).

After independence the Government of Zimbabwe (GOZ) implemented an equitable social welfare policy. This policy was introduced specifically to readdress the disparity in social services such as education, curative and preventive health provision amongst the rural poor (Barry and Thomas, 1990). In 1984, a white paper, *Planning for equity in health* (GOZMOH, 1984) was approved, in which the health policy became consistent with economic policy, enshrined in *Growth with equity* (GOZ, 1984). Implementing the WHO strategy 'health-for-all' by the year 2000 (WHO, 1979), the Zimbabwean Ministry of Health (MOH) developed a country specific action plan (GOZMOH, 1985). The main aim of the policy was to readdress existing imbalances in the level of health care between various sectors of the population, to favour in particular the underserved rural areas (Male-Mukasa, 1986).

Public health expenditure was in the region of US$15-20 *per capita* for most of the 1980s, this approximated to 6-8% of national budget, the proportion was nearly three times that of Kenya or Nigeria and over twice as large as Egypt, a country with nearly the same level of GNP *per capita* (ACC/SCN, 1993). The success of outreach health programmes being epitomised by the Expanded Programme of Immunisation (EPI) which obtained nearly a two-fold increase in immunisation rates from 56% to 74% between 1983-88. Subsequently, Infant Mortality Rate (IMR) was reduced by a third from 80 to 53 per 1,000 live births between in 1982-1990 (Nkrumah and Nathoo, 1987; CSO 1989; ACC/SCN, 1993).

Other success stories equated with the post-independence period (1980-1990) such as national level food self-sufficiency in non-drought years have not had the anticipated positive impact on the population's health and nutritional status. Sen's (1982) entitlement approach explains the prevailing food security paradox of national level food adequacy and concurrent increase in chronic malnutrition rates amongst pre-school children in Zimbabwe. The root cause being related to an erosion of both exchange and endowment entitlements. Average household incomes increased moderately immediately after independence. However, an ensuing economic crisis further exacerbated by severe droughts experienced in 1991 and 1992, resulted in a substantial decline in real incomes and an erosion of liquid assets (Marquette, 1997).

The economic crisis was bought about by a combination of contributory factors. The Economic Structural Adjustment Programme (ESAP) was introduced against a background of a large fiscal imbalance, declining tax revenues and commodity prices, economic stagnation and record levels of unemployment (Marquette, 1997; Potts and Mutambirwa, 1998; Chattopadhyay, 2000). Massive balance of payments crisis exacerbated by the 1991/2 drought meant ESAP required the GOZ to reduce spending further by imposing wage restraints, reducing subsidies and cutting social spending. This led to a sharp increase in the cost of living; the composite price index (CPI) rose by a factor of 4 between Oct-91 and Dec-96; over the same 5 year period food prices trebled (IMF, 1997; EIU, 1999;). Within the first 6 months of ESAP grain prices increased by

60% (Kanji and Jazdiwska, 1993). Health and education expenditure were also drastically reduced, subsequently reducing the provision of preventive outreach programmes (Renfrew, 1992; Potts and Mutambirwa, 1998).

A direct consequence of the 1990s economic crisis has been static infant, child and maternal mortality rates and only a slight decreased prevalence of child undernourishment. The 1994 Zimbabwe Demographic Health Survey (ZDHS) indicated that child survival rates had not improved between 1985-1989 to 1990-1994 (CSO, 1995). In 1988, the estimated IMR and Child Mortality Rate (CMR) were 53 and 75 per 1,000 children, respectively (CSO, 1989). These estimates remained virtually constant over the following five years. In 1994, the IMR and CMR were 51.2 and 75.9, respectively (CSO, 1995). For the same five year period there was a 6% decline in the prevalence of stunting[2] from 30% to 24% amongst children aged 3-35 months. In contrast, the prevalence of wasting[3] increased from 1-6%. The static trend in mortality and malnourishment rates have been attributed to recent worsening economic situation, direct impact of the AIDS epidemic and diminishing returns from simple health and nutrition targeted interventions that had been responsible for earlier improvements in child survival. The reduction in Government expenditure particularly social services, health and education implemented as part of the structural adjustment reforms have also been implicated to the lack of improvement in health. In addition, the season of data collection including rainfall patterns, exposure to infectious diseases can explain the large fluctuation in the prevalence rates of wasting (Macro/MOH/UZ, 1996).

Until basic underlying cases of such poverty are addressed, it is predicted that the relatively high rates of mortality and malnutrition will persist in Zimbabwe (World Bank, 2000). Poverty is inextricably linked to nutrition (Szal and Thorbecke, 1986) the poor worldwide are more likely to suffer from both forms of chronic malnutrition, under and over. Generally, the rural sectors, particularly subsistent agricultural households, are consistently considered the most vulnerable sector (Horwitz, 1989).

[2] *Stunting was defined by the ZDHS as< -2 SD Height for Age Z-score (HAZ) NCHS reference median*
[3] *Wasting is defined by the ZDHS as -2 SD Weight for Height Z-score (WHZ) NCHS reference median*

More than 75% of the poor in sub-Saharan Africa and South Asia are rural people (UNDP, 1999). This is the case within Zimbabwe. The most recent Poverty Assessment Report conducted in 1995 estimated that 61% of the total Zimbabwean population were 'poor' with an income below a level sufficient to provide basic needs. Whereas 75% of all rural households were categorised as 'poor', the communal agricultural sector exhibited the highest (84%) rate of abject poverty (MPSLSW, 1996).

The livelihoods and welfare of subsistent farmers are amongst those most affected by the economic crisis experienced in Zimbabwe during the 1990s. The lack of viability of agriculture in the drier agro-ecological zones, high levels of rural employment, poor pay and lack of job security of seasonal workers make subsistent agriculturists one of the most vulnerable segments of the Zimbabwean population to price fluctuations (Mehretu, 1994; Jayne *et al.*, 1994). The majority of rural poor are subsistent agriculturists relying on the environmental resource base for their livelihood. The small-scale farmer in sub-Saharan Africa is responsible for their own and the nation's food security and national economic development. Technological advances in agriculture are slow and poorly distributed (Rukuni, 1994). Hence, for the foreseeable future, the small-scale farmer will be engaged in high levels of physical activity that subsequently impose substantial demands on food requirements. To increase the nation's economic development in general and agricultural productivity in particular it is imperative that the rural population are adequately nourished from conception through to old age (Scrimshaw, 1997). The case for investing in nutrition makes economic sense (World Bank, 1992; UNICEF, 1997, Martorell, 1999; UNU, 2000), improves productivity and economic growth (Spurr, 1987) and promotes education, intellectual capacity and social development (Pollitt, 1990).

The economic productivity argument for adequate nutritional status has been recently surpassed by a far more powerful debate; that of human rights where adequate nutrition is perceived not only as a basic human need but a fundamental entitlement (Spitz, 1985). The human rights-based approach recognises that nutrition is a key universal factor that affects, as much as it defines, the health of all people

(Brundtland, 1999). Essentially, human rights are the relationships between claim holders and duty bearers (World Alliance for Nutrition and Human Rights, 1998).

The fundamental principles of the human rights approach stipulate that Bearers have a duty to respect, protect, facilitate and fulfil the rights of claim holders. Applying this to nutrition it means that the Bearers (e.g. governments) have a duty to supply the appropriate combination of energy and nutrients using safe hygienic conditions and sustainable practices and the claimants (population) have a right of freedom from want (Haddad, 1998; Haddad and Oshaug 1998). The gap between recognising and achieving this goal is evident when examined from both sides of the nutrition security equation. The disparity between nutrition inputs and outputs is particular stark when rural and urban sectors are compared within countries, such as Zimbabwe (Atkinson, 1992). In 1994 ZDHS, approximately, a third (34.7%) of rural population used unprotected water sources for food preparation whereas almost all (99.8%) the urban population had access to potable water. Over half (50.1%) the rural population had no access to sanitation compared to 99.9% in the urban areas (CSO, 1995). In addition, to the problem of availability, the magnitude of the time and energy costs associated with routine domestic activities such as the collection of water and firewood, are relatively less constraining in urban settings but extremely crucial for the rural area; requiring about 25% of the daily time and energy budgets for each household member (Mehretu and Mutambirwa, 1992). Similarly, a large variation in access to education was also observed in 1994 ZDHS between urban and rural sectors; nearly a fifth (19.1%) of the rural female adult population had no education compared to 5.3% female urban residents (CSO, 1995).

The variation of nutrition inputs between the urban and rural sector is reflected in the divergent prevalence rates of malnutrition amongst pre-school children (3-35 months). The incidence of underweight and stunting are 5.7% and 5.9 % higher, in rural areas compared to the urban sector. Similarly, the patterns of adult underweight mirror the distribution of child malnutrition. The prevalence of chronic energy deficiency (CED) amongst rural women was 3.7% higher than their urban counterparts (CSO, 1995).

In addition, the phenomenon of seasonality compounds the already distorted access to food and exposure to disease between the urban and rural sectors and exponentially increases the nutritional vulnerability profile of the rural poor (Payne and Lipton, 1994). Subsistent farmers residing in a uni-modal climate dependent on rain-fed agriculture are the most at-risk of experiencing large seasonal fluctuations in the food supply (Ategbo, 1993). Seasonality is recurrent, many subsistent agriculturists have developed a set of coping strategies designed to mitigate the impact of seasonality (Corbett, 1988; Reardon *et al.*, 1988). Actions developed to alleviate seasonal food stress range from household resource adjustments including outward migration (Chambers, *et al.*, 1981; to individual level biological and behavioural adaptations (Bayliss-Smith, 1990; Ferro-Luzzi and Shetty, 1999).

Despite these glaring disparities between rural and urban life, the food security and nutrition research agenda in the past decade has been diverted. Emphasis is being given to the emerging problem of urban malnutrition in response to the rapid influx of rural inhabitants to over-crowded urban centres during the 1980s and 1990s (Loewenson, *et al.*, 1983; Masanganise and Waterston, 1983; Atkinson, 1994). Population projections suggest that by 2015, nearly half (49%) of the total population of developing countries will be living in urban centres (FAO, 1998). Conversely, half of the population will continue to live and work in rural communities.

Importantly the urban and rural demographic profiles differ significantly. The lack of employment opportunities within the rural area has caused mass male migration, a phenomena set to continue. Typically women, children and the elderly remain within the rural community and are largely responsible for agricultural production. All three groups are universally regarded as physiologically vulnerable segments of the population (Mclean, 1984). On this basis alone it can be argued that the urban and rural populations do not have equal probabilities of nutritional risk and hence should not be treated as competitors for scarce nutrition resources. The present diversification of nutrition research agenda is seemingly short sighted "treating the symptoms rather than preventing the problem". As argued above, the optimal health and nutritional status of the subsistent farmer is imperative to maintaining national and household level food security and economic development. Hence, urban and rural nutrition problems need to be treated in synchronisation not in isolation, as the welfare of one is dependent on the other.

The broad facts, increasing prevalence of chronic child malnutrition, vulnerability of the rural population profile, low productivity, high risk of seasonality combined with disparity in the availability and access to nutrition resources all provide a convincing case for studying the nature of chronic malnutrition amongst the rural poor.

1.4 General objective of the study

The general objective of the study was to analyse the prevalence, severity and causes/origins/risks of chronic malnutrition amongst and within subsistent agricultural households in Zimbabwe. A comprehensive longitudinal food, health and anthropometric survey of 354 households was carried out in Buhera District, Zimbabwe providing an invaluable opportunity to explore some of the above assumptions associated with pre-school anthropometry. To capture both the seasonal dynamics of the nutrition situation and intra-household nutritional status, all household members were measured three times during the year. Anthropometric indices were used as proxies of child and adult nutritional status. To identify the main risks and determinants of nutrition security, a set of simple indicators used as proxies for dietary intake, health status, care and household welfare were estimated and associated with anthropometric status.

1.5 Specific Objectives

The specific objectives of the thesis are:

1. Assess the level of chronic malnutrition amongst members of subsistent agricultural households in Buhera District, Zimbabwe using anthropometric measurements.
2. Evaluate the seasonal dynamics of chronic malnutrition by measuring the absolute and relative change in body weight and mid-upper arm circumference (MUAC) and

linear growth in children. To identify which specific groups by age and gender are vulnerable to seasonal food shortages.

3. Identify the main factors (morbidity, household food security, demographic, socio-economic and environmental) associated with adult and child malnutrition.

1.6 Overview of Thesis

This thesis consists of eight chapters.

Chapter 1 - provides the problem statement, salient background information and the rationale for the thesis. It states the aims and objectives and includes a short summary of the content of this thesis.

Chapter 2 - provides a detailed review of the literature associated with chronic malnutrition. The literature review has four sections. The first section discusses the definitions of terms related to chronic malnutrition; the second section briefly reviews the contribution of nutritional sciences in curing and preventing chronic malnutrition. The third section reviews the literature pertaining to the theoretical and technical use of household calorie adequacy and anthropometry as measures of nutritional status. The fourth section presents an array of conceptual models of nutritional status and nutritional risk factors including dietary intake, morbidity, demographic and socio-economic variables that have been used to examine the association or relationship between nutritional status and determinants.

Chapter 3 - details the research methodology. The chapter has four parts. The first part provides an overview of the conceptual framework used to link nutritional status with household food security, individual health status, household demography, socio-economic status and environmental conditions. The second part outlines the methods used to analyse each respective objective. The third part details the data analyses including the study definitions and an outline of the parameters used to construct the dependent and independent variables. The fourth part provides information pertaining to the empirical framework including details of the study design, criterion used to select the survey site, the sampling strategy and data collection techniques. Within this section data management, cleaning and processing procedures are documented.

The results of the data collection and analyses are presented in Chapters 4, 5, 6 and 7. *Chapter 4* - Describes the demographic profile of the sample population and the prevailing socio-economic conditions of the survey area at the time of study. This chapter particularly addresses the problems associated with defining a household and a resident within a transient population and the difficulties associated with demarcation and measurement of welfare and wealth amongst the rural poor.

Chapter 5 - Summarises the results from the cross-sectional analyses of the anthropometric measurements. This includes the determination of the level and magnitude of chronic malnutrition problem amongst the population by age and gender.

Chapter 6 - Presents the results of the 12-month longitudinal anthropometric study carried out between Nov-94 to Nov-95. An evaluation of the seasonal dynamics of nutritional status amongst household members is presented by age and gender.

Chapter 7 - Examines the association between anthropometric status, household food security, individual health status and demographic, socio-economic, environmental factors, the relative and simultaneous contribution of each to anthropometric status are evaluated.

Chapter 8 - This final chapter discusses the implications of the findings presented in chapters 4, 5, 6 and 7 with comparative results from the literature and previous empirical research studies. Focusing on the total and relative contribution of household food security, health status, demographic, socio-economic and environmental factors to the change in prevalence of underweight, stunting, CED, and poor weight gain or negative weight change within and between the sample population. Conclusions and policy implications and areas of further research are presented.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

To begin to understand the nature, dimensions and challenges of the problem of chronic malnutrition, it is necessary to identify and examine specific factors that may have contributed to its unabated persistence. The literature review has three sections. The first section explores the difficulties associated with defining chronic malnutrition concentrating on the various nomenclatures used to capture the nature of the condition. The second section focuses on the theoretical and technical difficulties associated with the assessment of nutritional status, particularly its measurement and quantification amongst the free-living. The third section outlines the conceptual models used to explain and predict the aetiology of chronic malnutrition.

2.2 Defining chronic malnutrition

The lack of consensus over the use of specific terms related to chronic malnutrition has narrowed our vision in the past, of the symptoms and causes of the problem. For example the terms *'malnutrition'*, *'undernutrition'*, *'protein-energy malnutrition'*, *'mild and moderate malnutrition'*, *'growth faltering'*, *'growth retardation'*, *'failure to thrive'*, *'chronic energy deficiency'* are often used synonymously although distinctions exist and need to be clarified.

2.2.1 Nutrition, nutriture, nutritional status and nutrition security: there is not one standardised and internationally accepted definition of nutrition. Mendel (1822-84) defined nutrition as the "chemistry of life". Nutrition has been defined by WHO (1990) as *'a process whereby living organisms utilises food for maintenance of life, growth and normal functioning of organs and tissues and the production of energy'*. Nutriture and nutritional status are often used interchangeably in the literature, although they have essentially different meanings. *Nutriture* is a functional concept involving the dynamic process of 'intake' and 'expenditure' and 'utilisation', controlled by a series of biochemical reactions and interactions, whereas, *'nutritional status'* is a description of the physical result or outcome of nutriture (Dwyer, 1991).

Nutritional status is ultimately determined at the cellular level by '*adequate amounts*', in '*proper combinations*', and at '*appropriate times*' of '*sufficient energy*' and all the '*essential nutrients*' required for normal growth development maintenance, repair and functioning of the individual (Gopalan, 1992).

Nutrition security is a recent term introduced to capture the multi-factorial process involved in ensuring adequate nutritional status. Nutrition security is defined as the appropriate quantity and combination of inputs such as food, health services, and caretaker's time in order to ensure an active and healthy life at all times for all people (IFAD, 1994).

2.2.2 Malnutrition: refers to all deviations from adequate nutrition; it includes both under- and overnutrition, resulting from inadequacy, excess or imbalance of food intake relative to need or from poor absorption and utilisation of food consumed. Primary and secondary malnutrition are terms used to differentiate between food and disease related causes (Cassel, 1976; Solomons, 1988; de Onis *et al.*, 1999). Primary malnutrition is used to denote the inadequate quantity or quality of dietary intake while secondary malnutrition is characterised by additional influencing factors that interfere with the ingestion, absorption, transport, utilisation or excretion of the nutrients such as disease, other dietary components or drugs (Fuchs, 1990; Gopalan, 1992; Solomons, 1999).

Malnutrition is an essentially broad term that captures any physiological condition implying a notion of dysfunction or ill health, caused by an unbalanced diet. An imbalance either insufficiency, deficiency or excessive intake relative to requirement over time can result in functional impairment of nutrition-related capacities such as immunological competence (Garcia and Kennedy, 1994; Strickland and Ulijaszek, 1994), reproductivity (Allen *et al.*, 1994; Kusin *et al.* 1994), growth (Martorell, 1985), development (Sameroff and McDonough, 1984) physical work capacity (Immink, 1987; Spurr, 1987; Durnin 1994; Behrman *et al.*, 1995), physical performance (Meeks Gardner et al., 1990; Henneberg *et al.,* 1998), economic productivity (Behrman and Deolalikar, 1988; Dasgupta, 1993; Kennedy and Garcia, 1994; Strauss and Thomas, 1995) and cognitive function (Brozek, 1979; Buzina *et al*., 1989; Pollitt, 1990; Agarwal *et al*., 1998; Pollitt, 2000).

2.2.3 Undernourishment and undernutrition: Undernourishment refers to insufficient dietary intake whereas undernutrition is considered the physiological condition or an outcome of undernourishment. Undernutrition is equated with prolonged low levels of intake and/or poor absorption of food, of whatever kind. It is primarily caused by an inadequate intake of energy (kilocalories) and is generally described in terms of *macronutrients*, whether or not any specific *mirconutrient* is an additional limiting factor. *Undernourishment* is estimated from population and food availability data (FAO, 1999 and 2000). In contrast, the prevalence of *undernutrition* is estimated by measuring the degree of growth faltering, growth retardation or failure, and/or changes in body composition determined from the population's anthropometric status. *Underweight* is the universal term used to indicate that an individual is malnourished. There are two different *underweight* conditions: *nutritional dwarfism* (stunted but normally proportioned) and the original concept of *marasmus* (normal height but thin and wasted) (Golden and Golden, 2000).

2.2.4 Protein-energy malnutrition (PEM) or protein-calorie malnutrition (PCM): are two terms used to denote specific clinical symptoms associated with a cellular level deficit in energy and/or protein due to either inadequate dietary intake and/or poor utilisation (Alleyne *et al*., 1988). The two classical severe clinical syndromes associated with PEM are marasmus and kwashiorkor (Suskind *et al*., 1990). Marasmus occurs with overall shortage of food when protein is no more deficient than other nutrients; resulting in severe wasting of fat and muscle without oedema. Whereas, kwashiorkor was classically observed when the child's energy intake was adequate, but their protein intake was insufficient for growth resulting in oedematous malnutrition, with or without skin and hair changes and a fatty liver (Cecily Williams, 1933, 1935; McCance and Widdowson, 1968).

Until the late 1960s, it was accepted that these two classical syndromes represented extremes in a wide spectrum of childhood malnutrition. Counter-evidence has been accrued to indicate that the difference between the aetiology of kwashiorkor and marasmus is not so simple and definitive (Gopalan, 1968; Waterlow and Payne, 1975; Landman and Jackson, 1980; Alleyne *et al.*, 1988). By the end of the 1970s it was concluded that both conditions were the clinical outcome of chronic undernutrition and the differences between kwashiorkor and marasmus were ones of degree rather than kind (Waterlow, 1992; Phadke, 1994). The scientific debate is ongoing and different theories and hypotheses have been proposed to differentiate the pathogenesis of kwashiorkor and marasmus such as theories of free radical damage put forward by Golden and Ramdath, (1987). Presently, kwashiorkor is used with two different meanings: one as a synonym for 'oedematous malnutrition', and the other to denote the clinical syndrome where the changes in skin, hair, and fatty liver are part of the disease (Golden and Golden, 2000).

2.2.5 Mild to moderate malnutrition: has been defined as a level of dietary intake of energy and/or specific nutrients that is below the recommended daily allowance, which is associated with less than adequate physical growth and/or change in metabolism, but not to the degree that would lead to significant wasting, stunting or clinical symptoms (Wachs, 1995). Mild malnutrition is described as a condition in which non-specific clinical signs, as well as non-specific laboratory indices, are present, without any of the classical manifestations of nutritional deficiencies (Béhar, 1981). Accepting that there is a relationship between the loss of body mass and increasing dysfunction and that this relationship is neither linear nor that of a sudden threshold, but curvilinear or exponential then malnutrition can be described as causing a gradual but accelerated risk of morbidity which may start at quite modest deficits of loss of body mass or diminished food intake, as explained earlier the majority of undernourished children world-wide are mild or moderately malnourished (de Onis *et al.*, 1993).

2.2.6 Growth faltering: is detected by serial recordings of individual weight and height. The measurement of weight and height velocity emphasises the direction of growth. No change in height or an actual decrease between successive weight measurements is taken as a sign of growth faltering whereas adequate growth is reflected in a measurement tracking in parallel to the expected weight and/or height gain (Beaton, 1989). Since, the decline in the rate of weight gain (velocity) is more sensitive than the decline in linear growth, serial measurements of weight are essential for providing the earliest warning of growth faltering. Unlike attained weight and height, there is not an internationally recognised reference for measuring or criteria for establishing inadequate growth velocity. Practitioners have suggested that a loss of >1 SD Z-score/90 days or a decrease >2SD/ 90 days or a drop in two more percentile categories from a previously established growth channel on a growth velocity chart denotes the need for intense child surveillance and investigation into the causes of the deviation (Nichols, 1997). One of the main difficulties associated with measuring growth is the need for longitudinal data; hence, growth faltering at the population level can only be inferred by averaging measures from cross-sectional data sets (McMurray, 1996). Generally, focusing on rates of weight gain by age rather than the growth trajectory (up, flat, or down) is considered impractical in the majority of growth monitoring settings (Martorell and Shekar, 1994) and a complicated concept to communicate to carers (Morely, 1996).

2.2.7 Failure to thrive (FTT): This is an all-embracing dynamic term that captures the negativity of the lack of growth overtime, since to thrive is to growth "strongly and vigorously". 'Failure to thrive' is the reverse, identified by slow or cessation of gain in height to weight at the expected rate (Raynor and Rudolf, 2000). FTT refers to growth rates rather than absolute size. Hence, children who are born small for gestational age remain short and lightweight throughout childhood but are healthy and grow virtually parallel to a normal growth pattern. These children are not categorised as failing to thrive, since their growth velocity is adequate, rather they are small but not truly failing to thrive (Poskitt, 1991). Both, growth faltering and failure to thrive describe the process of poor growth velocity. The fundamental difference between growth faltering and failure to thrive is that the latter implies failure not only of growth but also of other aspects of a child's well-being or functional capacity including developmental and behavioural characteristics. FTT is a term generally used by paediatricians in clinical hospital settings whereas growth faltering is the term used by nutritionists when monitoring child growth in clinics.

2.2.8 Growth failure or Growth retardation: Growth failure or growth retardation both refer to attained or achieved body size that mark the process of failing to grow and the state of having failed to grow. Growth retardation is used in relation to either weight or height. However, it should be recognised that there is a fundamental difference in the biological processes of a weight or height deficit.

In addressing the biological significance of growth retardation, a number of terms are used to differentiate between a weight and height deficit. Seoane and Latham *et al.,* (1971) called these conditions '*acute*' and '*chronic*' malnutrition, whereas Waterlow (1974) introduced two purely descriptive terms of what was observed, '*wasting*' and '*stunting*' to characterise the deficits of weight and height and the processes that cause them. Waterlow (1974) argued that the terminology suggested by Latham implied more than what was known in the manifestation of each condition.

Wasting: indicates a deficit in tissue and fat mass compared with the amount expected in a child of the same length or height, and may result from failure to gain weight or from actual weight loss. One of the main characteristics of wasting is that it is a more transient condition than stunting it can develop very rapidly, and under favourable conditions is alleviated swiftly (WHO, 1986). The highly sensitive nature of body weight to nutrition disturbances explains its association with the term 'acute'. Wasting tends to occur during the weaning period or in the second year of life, after which time its prevalence tends to decline. Internationally (WHO, 1995) wasting is diagnosed using anthropometry. Children with a weight for height Z-score (WHZ) <-2 SD of the NCHS growth reference median are classified as 'wasted'.

Stunting: signifies slowing in skeletal growth. The term 'stunting' is considered a velocity term and 'stunted' a distance term. A child's growth rate can be reduced from birth, but a significant degree of stunting, representing the accumulated consequences of retarded growth, may not be evident for some years (WHO, 1986). Waterlow (1994) cautions that stunting can become evident by the age of three months and thus may not always be classified as chronic malnutrition. Children with a height for age Z-score (HAZ) <-2 SD of the NCHS growth reference median are diagnosed as 'stunted' (WHO, 1995).

Underweight or Lightness: (weight-for-age WA) is used to determine if a child is (light) underweight or (heavy) overweight compared to a healthy child of the same age. WA is a composite index reflecting both the height and weight of the child. Low WA is associated with current or acute malnutrition or infection. A child who has previously received adequate nutrition, but is currently experiencing a short-term episode of reduced food intake or infection, would typically have normal HA and low WA. It has been shown that the HA and WH indices account for more than 95% of the variance in WA. WA is difficult to interpret because it does not distinguish between short children of adequate body weight and tall, thin children (Gorstein, *et al.*, 1994). When used on its own, WA is a better indicator for children up to age one year than for older children, because weight is obviously related to height. In some African countries up to 50 per cent of young children are stunted, but half of them are within the normal range for WA, and otherwise healthy apart from their small stature. Older children who have low HA may also have low WA, even if they are not currently malnourished. In this case, if only one cross-sectional measurement is available, WA alone does not distinguish acute (short-term) malnutrition from low weight associated with smallness of stature or chronic (long-term) malnutrition (Waterlow *et al.*,1977). This limitation of WA applies particularly to cross-sectional data, but less to longitudinal surveys, where repeated measurements are taken and trends can be observed (McMurray, 1996).

2.2.10 Chronic energy deficiency (CED): is a condition which is applied to adults who are not only underweight for their height but also constrained in their physical activity by inadequate food intakes. The term CED was coined to infer that the principal problem was one of persistent deficiency of dietary food supplies whereas the term underweight was considered too neutral (James, *et al.* 2000).

The original measure used to diagnose CED involved the measurement of body weight, height, energy intake (or expenditure) and finally the basal metabolic rate (BMR) (James, *et al.*, 1988). This original measure of CED was modified and redefined in simple terms by using specific levels of Body Mass Index (BMI). BMI is estimated by dividing weight (kilograms) by the square of height (metres^2) (Shetty and James, 1994; Bailey and Ferro-Luzzi, 1995). The simplified classification of CED using BMI alone has been accepted by WHO (WHO, 1995) and FAO (Shetty and James, 1994) and now allows a rationale approach to monitoring the changes in the adequacy of food supplies and the impact of such major issues as seasonal changes in food security (Ferro-Luzzi *et al.*, 1994) and the degree of nutrition transition (Martorell *et al.*, 2000) at the population. The sensitivity of BMI as a measure of the body's energy stores- excess or depletion is still being questioned particularly since different bone structure and variations in lean/fat ratios between individuals can be marked (WHO, 2000).

2.2.11 Overweight and obesity: Over-nourishment occurs when intake of energy exceeds expenditure, the excess is stored in the form of triglycerides in the adipose tissue. The expression of overweight requires a certain level of food availability; it is always a product of positive energy balance resulting from relatively low energy expenditure and/or relatively high-energy intake (Garrow, 1999). Obesity is defined as the degree of fat storage associated with elevated health risks such as increased incidence of mortality and morbidity (WHO, 1995; WHO 2000). BMI is also used to define grades of obesity. The BMI cut-off points used to differentiate between the undernourished, adequately and overnourished are now commonly used at the individual and population level, these are outlined in Chapter 3.

2.3 Theoretical and technical difficulties associated with the assessment of nutritional status amongst the free-living

The assessment of a "state" or "status" with respect to nutrition is in the realm of diagnosis. Diagnostic measures, usually performed in free-living subjects, are required to assess either an individual's status (clinical) or a population's degree of risk (epidemiologic) (Solomons, 2002). The usual process of developing a method to diagnose a condition is to accumulate knowledge of the mechanisms that result in either a single symptom or set of symptoms related to a causal agent. The unspecific nature of chronic energy malnutrition, the lack of a specific causal agent, missing chemical entity within the diet, disease organism, or the presence of a particular toxic substance in the environment and the lack of a distinct syndrome means that it is complicated to diagnose (Payne, 1992).

2.3.1 Rationale for using multiple indicators of nutritional status: Nutritional status assessment usually includes anthropometric, dietary and biochemical measurements, clinical history, and physical and other data (WHO/FAO/IUNS, 1973). Ultimately, the type of nutrition assessment technique used is determined by the objectives of the study the level of reliability (precision and discrimination) and the validity (how close it is to the 'true' value) or accuracy of the measure required (Solomons, 20002). As the majority of nutrition indicators are not specific or precise enough to be indicative of a specific cause of malnutrition, it is necessary to embark on a process of differential diagnosis combining many different types of information to confirm or refute hypotheses about cause (Wadsworth, 1984). Since, few indicators are unambiguous in themselves, several indicators are required to make a definitive diagnosis of the degree of deficit (Dwyer, 1991).

The rationale for using multiple indicators of nutritional status has been justified by Dwyer (1991). The different types of indices reflect the heterogeneity of nutritional status and the methodological limitations in measuring nutritional status. Since many forms of malnutrition exist there is no single indicator, nor are the specific types of indicators appropriate for all circumstances. Sahn (1984) has developed a generalised scheme of the development of a nutritional deficiency equating each stage of depletion with an appropriate method of nutritional assessment. Suskind (1990) suggested that a new nutritional scoring system should be devised that would synthesis these assessment techniques to increase the specificity of the diagnosis. This is an ongoing debate (Osmani, 1992). Given the definition of chronic energy malnutrition and undernutrition as an inadequate dietary intake or poor growth; two sets of proxy indicators are generally used, one measures nutrition inputs such as kilocalorie adequacy and the other nutrition outputs such as growth or body composition (DeRose, *et al.,*1998).

2.3.2 Dietary assessment-conceptual and technical limitations: Since, the primary cause of malnutrition is the inadequacy of dietary intake theoretically an ideal measure of undernourishment involves the comparison between dietary consumption and physiological requirement. From a conceptual perspective, the sole use of kilocalorie adequacy is limited, since food security is not synonymous with nutrition security (Pelletier, *et al.*, 1995). From a technical perspective, to determine the adequacy of dietary intake requires answers to two separate questions: what are people eating, and how much do they need? The former question is conceptually straightforward, but in practice requires large amounts of data and estimation is problematic. The latter question is more complex. Significant difficulties are encountered both in measuring dietary intake and in defining physiological requirements against which intake can be compared (De Rose *et al.*, 1998). With these caveats, the methods used to collect dietary intake data, approaches used to establish nutritional requirement and ascertain dietary adequacy are outlined.

Methodology of dietary assessment: Food consumption data is generally collected at three levels of aggregation, national or geographic region, household and individual. At each level the conceptualisation and specific component of food security (availability, access and utilisation) captured differs, as do the methodologies and limitations of data generated. The methods for collecting information on dietary intake vary in their validity, reliability, precision, and whether groups or individuals are the focus of interest (Block, 1982; Bingham, 1987; Pao *et al.*, 1990).

There are two basic methodologies used to assess dietary adequacy at the national and household level, the 'status quo' method and the 'nutrition-based' method (James and Schofield, 1990). The status quo method estimates food energy requirements based on food supply. Primarily used by economists and agriculturists the calculations are based on two assumptions. Firstly, food availability during the base period is sufficient to meet food needs and secondly food availability is equal to food consumption. However, mean energy values calculated from food availability has no validity in physiological terms. In contrast, the nutrition based method estimates energy requirements according to *biological demand.* Energy estimates are based on the demographic composition of the household, district or nation. The number, gender, age, body weight, health status and estimated physical activity patterns of the population are used to derive a more meaningful assessment of the amount of food required (James and Schofield, 1990). These are discussed in more detail below.

National level estimates:

Estimates of national food supplies for most countries are maintained and regularly updated by Food and Agricultural Organisation (FAO). These estimates are based on food balance sheets (or food disappearance data or consumption level estimates), which involve detailed analyses of national food systems (FAO, 1983, 1984). These estimates are generated from food balance sheets by summing the amount produced, imported or withdrawn from carry-over stocks and then subtracting amounts lost in processing, transport, used for purposes other than food consumption (seed, animal feed, industrial raw material), exported, or stored for later use. Estimates of the nutrient content (calories, protein and fat) per unit of each food are then multiplied by the amount of the food available to obtain estimates of the total amounts of each nutrient available from each foodstuff. These are summed across all foodstuffs to obtain total supplies of each specific nutrient. The final step is to divide national totals by the number of days in the period to which the supply data apply, and by the total number of people in the population. The FAO national level estimates of energy (kilocalories), protein, fat *per capita*, per day are an essential part of assessing the magnitude and extent of world food insecurity. Food balance sheets are designed to present a comprehensive picture of the pattern of a country's food supply and an estimate of the quantities available for human consumption during a specified reference period.

The accuracy of consumption estimates derived from food balance sheets have been extensively questioned ultimately they are dependent on the reliability of the underlying statistics of food supply and utilisation and of population numbers. Coverage and representativeness of the basic data is a major practical issue. Since, production data is generally confined to commercialised major food crops, non-commercial or subsistence-level production are usually not included. Subsequently, national level food availability data is generally biased towards affluence since developed countries have advanced statistical systems to generate more complete data. The incompleteness and inaccuracy of the basic production data are a major limitation of national level estimates generated for developing countries. This leads to under-estimation for low income countries and over-estimation of consumption for higher income countries (FAO, 1998). Hence, the national level estimates have low precision due to missing data or systematic errors, these errors are often unquantifiable and the direction is also unknown (FAO, 1998).

Svedberg (1991) has argued that the FAO's food balance sheet approach underestimates food availability in sub-Saharan Africa relative to other regions. Food production data in sub-Saharan Africa is subject to extreme inaccuracies particularly in countries such as Zimbabwe where much of the food produced is consumed without ever entering the market and a number of lesser known wild foods are commonly gathered and consumed. Production estimates are further hindered by continuously harvesting at irregular intervals or not completely harvesting, particularly food security crops such as cassava and plantains. Other foods are often completely excluded such as wild game and insects. In addition, import and export estimates are hampered by informal cross-border trade.

National level estimates also lack validity since information pertaining to access to supply within a country or between seasons. Zimbabwe typifies this analogy. A paradoxical situation has been observed in non-drought agricultural cycles when adequate national level food supplies far exceeds population requirement yet concurrently within the same year many households are reported to be food insecure and child malnutrition remains high (Tagwireyi and Greiner, 1994). Despite the imprecise nature of food balance sheets because they are collected yearly, using a standard methodology they can provide valuable information to explore the relative magnitude of year-to-year fluctuations in food availability (Atwood, 1991) and assess shifts in consumption trends (Henderson Sabry, 1988).

Household level-dietary estimates:

Household surveys, if obtained from a representative sample provide an alternative estimate of national food supplies *per capita* and are considered an indispensable data source for exploring the association between food availability, access and distribution within a population. Concurrent collection of consumption, demographic and socio-economic data can be subsequently used to define income levels necessary to ensure food security and identify the main characteristics of food insecure households (Biró *et al.*, 2002). This type of analysis provides an invaluable insight into the dynamics of food security within a region that can be subsequently used by policy and programme makers for targeting purposes (Smith, 1998).

The purpose of the food consumption survey ultimately determines data requirements; economic purposes estimate the *gross* household food supply and the amount of money spent. This methodology is used by household budget surveys such as the multi-purpose Living Standards Measurement Survey (LSMS) sponsored by the World Bank which merge aspects of income, expenditure and consumption. Similarly, the cost of a food basket derived from consumption data are used to ascertain the proportion of the population below for the food poverty line, an integral component of the poverty assessment surveys implemented and published by United Nations Development Programme (UNDP, 1995). In contrast, a food consumption survey for nutritional purposes estimates the *net* food supply or availability of nutrients focusing more on the amounts and nutrient composition of foods than their economic value. Both, types of survey use the household, family group or institution as the main unit of observation; quantities of foods purchased and eaten and consider the optimal sample size and number of days to observe (Henderson Sabry, 1988).

The principal survey methods used at the household level include a *food account* which involves the main food preparer recording the weight and where possible price of all food entering the household for human consumption. Or, the *food inventory* which involves a field worker listing all food in the household at the beginning and end of the survey period. Weights of all foods brought during the interim period are also recorded. The only difference between the account and inventory method is that changes in the food stocks are measured using the latter approach. Alternatively, the household *record* method provides a complete account of the food consumption for all subjects during the study period including food eaten outside the household and subtraction of the foods utilised by non-residents. Whereas, the *list-recall* method uses a structured questionnaire to assist the respondent to recall the amount and price of all foods used and purchased during the study period (Flores and Nelson, 1988).

The type of survey method used is ultimately dependent on the proportion home produced and procured; food preparation techniques; level of accuracy required - indirect adjusted gross versus direct net amounts of food available for consumption; the degree of literacy of respondent (Kigutha, 1997); the number of interviews available and the time period to be studied (Biró *et al.*, 2002). The food account and inventory methods are suitable for estimating gross food supply and providing economic data in areas where foods are mainly purchased and the level of literacy is high. In comparison, the household record method is valuable in providing direct estimates of the net food available, particularly in subsistent communities where a large proportion of food is home produced and the level of literacy is low (Nelson, 2000). Overall, the supply versus consumption methods of estimating household level food availability often yield very different results. Empirical evidence suggests that food expenditure data generally underestimate energy availability as only the food consumed at home is included within the estimate (Bouis *et al.*, 1992).

There are a number of sources of error associated with household level food consumption surveys. Many record food available not actual consumed; food wasted, or given to visitors or pets may be incorrectly included within the estimate; food obtained from outside the household is often not recorded subsequently the results generated relate to only part of the diet; certain foods may not be recorded, misrecorded, and purchasing patterns can be distorted by measurement process (Hollingsworth and Baines, 1961; Nelson, 1999).

Consumption data at all levels can also be fundamentally flawed if the timing and duration of the study are not taken into account (Nelson, 2000). Food consumption and expenditure vary considerably over time and are difficult to estimate with any degree of accuracy over a short period of time particularly in areas that are prone to seasonal changes in food availability and access. In subsistent agricultural communities which solely rely on one harvest per year, a food consumption survey taken just prior to harvest when food is scarce may result in a high proportion of households being classified as food insecure whereas a survey taken a few weeks later there could be a situation of abundance (De Rose *et al.*, 1998). Although statistical adjustments are possible (National Research Council, 1986), this problem often goes unrecognised and therefore uncorrected. Neither situation accurately characterises the population's usual access to food. The compelling reality for understanding who is food insecure may actually be the wide swings between scarcity and abundance rather than the mean level to which these two levels equate (De Rose *et al.*, 1998). Recently a variety of household level food security indicators have evolved from empirical work designed to encapsulate both food availability and access, including aspects of the food economy (Boudreau, 1998) and the frequency and severity of coping strategies (Maxwell, 1996; Maxwell, *et al.*, 1999).

Equally the importance of dietary diversity particularly for child growth is being understood and subsequently incorporated in food security profiles. The conversion of food consumption data into energy intake requires average calorific values for each food item consumed (West and van Staveren, 1998). Many developing countries do not possess their own food composition tables, relying on data from countries which consume a similar diet, these may be incomplete or inaccurate particularly for food security crops such as wild leaves and fruits. The conversion factors of energy are also prone to errors due to the lack of consideration of the moisture content (Southgate and Durnin, 1970). Since, kilocalorie adequacy provides a quantitative and not necessarily a qualitative measure of the diet, simple dietary diversity indicators including the number of food groups or unique foods are being successfully developed and validated (Hodgson, 1994; Kant, 1996; Hatløy *et al.*, 1998; Hebert, 2000; Stookey *et al.*, 2000) against more sophisticated measures of dietary quality including Nutritional Adequacy Ratios (NAR), Mean Adequacy Ratios (MAR) or Index Nutritional Quality (INQ) that are estimated from weighed food records (Gibson, 1990).

The main limitation of household level consumption data is the lack of information pertaining to intra-household distribution (Selinus *et al.*, 1971). The semi-weighed technique has addressed this problem by recording the diet of every household member individually (Nelson and Nettleton, 1980). It is more common to estimate the calorie intake of the entire household and not of individual members. The actual calorie intake of household members is often indirectly derived through the application of certain arbitrary coefficients based on the assumption that the intra-familial distribution of food conforms relative to physiological needs. However, these coefficients such as consumption units may be invalid (McNeil, 2000).

The rules and processes governing the allocation of food within the household ultimately regulates the degree of individual level food security. Cultural practices can negatively influence the distribution of food, ignoring intra-household allocation of calories. Given the difficulties of obtaining and interpreting individual level dietary adequacy for large enough samples to support meaningful analysis, nutritional anthropologists have relied on inferences made from indirect indicators collected at the household level (Dettwyler, 1992). These dietary practices are often presumed to affect intra-household food allocation and have been interpreted as evidence of differential adequacy of diet for different members (Gross and Underwood, 1991). Such as, those who are served last at meals are assumed to receive less than a fair share (den Hartog, 1973; Katona-Apte, 1975; Maher, 1981; Papanek, 1990; Senauer, 1990). Similarly, customs that reserve particular foods for certain members are also cited as evidence of differences in access to dietary quality (den Hartog, 1972).

The assumptions surrounding differential access across gender and age groups within households requires further investigation. Empirical evidence suggests that the dietary energy and protein are often not distributed within the household in proportion to the physiological requirements of its members (Ferro-Luzzi *et al.*, 1981). The majority of studies show an unequal distribution of food with men consuming more than their share and younger members receiving less in proportion to their requirements. Svedberg's (1991) critique on "Undernutrition in Sub-Saharan Africa" rejects the hypothesis of female nutritional disadvantage within Africa concluding that the different roles of African (as compared with South Asian) women provide them with greater control over food which enables them to avoid nutritional deprivation for themselves and their children; an observation borne out in a number of studies (Chen *et al.*, 1981). The conclusion that females are discriminated against in access to food, rests disproportionately on studies from South Asia; explained as "The Asian Enigma" the subordination of women is highlighted as one of the main reasons (Ramalingaswami *et. al.,* 1997). To be able to surmise the impact of intra-household distribution of food it is necessary to measure dietary intake at the individual level.

Individual level-dietary estimates: Individual level data has the capacity to capture all three component of the food security equation (availability, access and utilisation). The data generated can facilitate the estimation of the adequacy of dietary intake and be used to examine the association between diet and health (Bingham, 1987; Willett, 1998). Only individual-level measurement can provide evidence of variations in malnourishment related to patterns of intra-household food allocation or other nutritional influences that affect people in the same household differently. Individual level dietary intake data can also provide an invaluable insight into the rules and processes regulating intra-household allocation, and opportunity to examine how the burden of household food insecurity is shared amongst members and describe the demographic characteristics of those suffering from food deprivation, and identify the possible reasons (discrimination or misunderstanding of individual nutrient requirements) why malnourishment exists within food secure households.

Technically, however it is difficult to capture all food consumed and measure nutrient intake amongst the free-living (Liu *et al.*, 1978; Olson, 1981). Individual dietary intake data is either ascertained retrospectively using recall techniques or prospectively using consumption records. Survey methods used at the individual level can be crudely divided into two categories, short term (24 h dietary recall or dietary record) and long-term instruments (food frequency questionnaire or diet history). Each survey technique has its own advantages and limitations (Barrett-Connor, 1991). Including the level of personal contact, applicability to broad population groups, level of literacy, length of time, expense, impact on intake, reliance on memory. Individual data collection is the most demanding level, in addition to ascertaining and recording the kinds and quantities of foods prepared, left over food needs to be estimated. Individual level data collection is prohibitively expensive and requires literate, motivated and willing participants if precise estimates are to be made. Hence, a sub-sample is generally used in population level studies for precise weighed food records.

The relatively simple, rapid dietary recall tools are considered valid for characterising current dietary intake of a population (Keys, 1979; Block, 1982). However, these methods have limitations being prone to recall errors, the accuracy being reliant on the respondents memory, literacy skills, the length of the FFQ and types of food listed (Olser and Heitmann, 1996; Dwyer and Coleman, 1997; Nelson, 1997). Past diet recall is strongly influenced by current intake and by diet patterns change (Pereira and Koifman, 1999). To overcome these limitations there is a need to develop new biomarkers of dietary items in primary validation studies (Bingham *et al.*, 1995)

Dietary requirements: Measures of food supply available to national populations, accessible to households, or consumed by individuals must always be compared with amounts required, in order to evaluate dietary adequacy. According to WHO (1985)

The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition, and level of physical activity, consistent with long term good health; and that will allow for the maintenance of economically necessary and socially desirable physical activity. In children and pregnant or lactating women, the energy requirement includes the energy needs associated with the deposition of tissue or the secretion of milk at rates consistent with good health.

These requirements vary across individuals and within individuals over time. They are influenced by gender, body size, physical activity level, age, reproductive status and disease. Additional factors that may influence include climate and dietary composition (Butterfield *et al.*, 1992; Miller, 1995; Whitehead, 1995; King, 1997).

However, by far the greatest source of variance of nutritional requirement is individual variability (Liu *et al.*, 1978; Dennis and Shifflet, 1985). For many nutrients intra-individual variability often exceeds that between individuals. Individual variability in energy and nutrient requirements, genetic endowment, response to diseases, and diet-related behaviours are immense. A precise assessment is not possible.

The most contentious and complex aspect of energy requirements relates to adaptation to a constrained diet (Shetty, 1999). Since, both inter- and intra- individual variation in energy requirements are large uncertainties pertaining to the range within which cost-free adaptation can occur, further complicates these decisions (Waterlow, 1999). Desirable patterns of growth for children and desirable patterns of physical activity at all ages are an important part of this controversy. Some analysts such as Sukhatme (1988) argue that intake and expenditure of dietary energy function as a self-regulating homeostatic system in which the efficiency of energy use is increased as intake decreases and decreased as intake increases. This technical argument has been taken as demonstrating "cost-free" adaptation to low intake, the possibility of maintaining not only energy balance and health but even usual activity levels on severely restricted consumption.

Others, such as Scrimshaw and Young (1989) and Waterlow (1989) have responded that adaptation to low intakes does not occur without undesirable limitation on physical activity. A proportion of the reduction in energy use that occurs as a result of reduced intake is apparently innocuous: weight loss itself causes some decline in caloric requirements, and less energy is used in digestion, absorption, and storage of nutrients when less food is consumed. However, the major mechanism for reduced energy expenditure are behavioural, and therefore not viewed as cost free.

The controversy surrounding the degree of adaptation to nutritional stress is also a source of policy debate directly affecting resource allocation (Srinivasan, 1981; 1988). Those who interpret adaptation to lower levels of energy intake as cost-free favour allocating resources more narrowly, focusing nutritional programmes on only those in extreme need. Gopalan (1982) describes this as 'Nutrition Policy of Brinkmanship' and illustrates that interventions of this kind have far less impact than programmes aimed at all levels of malnourishment. The cost-free adaptation underlies decisions by nutrition-monitoring organisations to define cut-offs for undesirable low caloric intake at levels two standard deviations below average requirements; thereby ensuring that the prevalence of hunger will not be overestimated. It has been suggested that the subsequent application of one cut-off point will misclassify individuals, this misclassification bias may not cancel out for the population and result in an over-estimation of the proportion truly malnourished (Srinivasan, 1981). Those who have higher estimates of the costs of moderate deprivation emphasis the needs of the marginally nourished. Their arguments tend to focus on the difficulty of emerging from poverty when productivity is limited by intake (Dasgupta and Ray, 1990).

Ultimately the determination of energy requirements is based on a value judgement. Implicit within any definition of dietary requirement a decision is made concerning desirable activity levels and growth patterns these can be calculated for either *survival, maintenance or optimum* levels (Bhargava and Reeds, 1995; Beaton, 1997). The choice of cut-offs for minimally adequate food intake influences both the estimates of food poverty and the comparability across samples. The FAO and the World Bank now accept common standards, but the thresholds of undernutrition which they used even in the recent past were defined differently (Uvin, 1994).

To summarise dietary assessment is also prone to errors at various stages of collection, analysis and interpretation; these can accrue to give an erroneous estimate. An accurate measure of the adequacy of food has to capture the aspects of seasonality and intra-household allocation of food and the variability of household composition and energy requirements. Hence, the results generated from the comparative analysis between intake and requirement should only be used as a general approximation of one dimension of the nutritional situation.

2.3.3 Anthropometric assessment: Anthropometric measurements are the most common indirect measure of age and gender variations in malnourishment. The theoretical premise or rationale for using growth and body composition as parameters of nutritional adequacy is based on the assumption that an inadequate energy intake relative to physiological requirement will lead to a negative change in body composition and poor growth. It is known that the human organism adapts to an inadequate diet by maintaining the integrity of its various metabolic and biochemical functions at the expense of growth.

Growth is considered a measure of man's adaptation to his physical environment, a summary measure of environmental influences (Martorell, 1985). As such it is increasingly being advocated and used as proxy 'living standards' (Ismail and Micklewright, 1997; UNDP, 1999). Child growth is considered a relatively early, sensitive and dynamic indicator of both individual and population level nutritional status. This assumption is supported by various types of empirical evidence, including secular trends in height with socio-economic development and supplementary studies (Osmani, 1992; DeRose, 1998). Equally body composition can also be used as a parameter of nutritional status as there is a 'normal' range of variation in the relationship between fat and lean body mass which reflects an adequate intake of energy and nutrients. Deficiencies and excesses in energy or nutrient intake, relative to biological needs, are associated with deviations in body composition from the norm (WHO, 1995).

Anthropometry, in a historical context, represented a descriptive aspect of natural science involving body measurement, classification, and correlation (Cameron, 1991). During the last half century the role of anthropometry has changed from describing the degree of malnutrition (Brozek, 1956) to diagnosing the nutrition situation, focusing on problem-oriented approach, monitoring change and impact of interventions. Conceptually, it is important to consider whether anthropometry describes or actually diagnoses nutritional status (Cameron, 1991). This issue relates to the biological validity of anthropometric indicators, that is the functional association between an external dimension such as height and weight to the internal milieu. A number of studies have suggested that there is a clinical mismatch between anthropometry and clinical and biochemical measures (Van den Broeck *et al.*, 1993.) suggesting that the common cut-off points used in anthropometry do not always imply a functional implication. Ultimately this conceptual issue is decided pragmatically, often governed by the availability of resources and type of study. In less developed countries anthropometry usually has a dual role as a descriptor and diagnostic tool used for screening such as, enrolment onto supplementary feeding programmes (SFP) (Cameron, 1991). In developed countries anthropometry is primarily used as an initial screening mechanism to identify children which require further biochemical and functional tests (Cross *et al.*, 1995).

Anthropometry is considered a objective method of nutritional assessment compared to clinical or dietary assessment and generally is less expensive than biochemical measures (Cross *et al.*, 1995). Anthropometric measurements provide a relatively quick safe non invasive comprehensive assessment technique which requires minimum input, equipment and training to acquire maximum output in the form of accurate reproducible results. Norgan (1994) summed up the virtues of anthropometric measurements as being 'precise (highly repeatable), accurate (close to the true value) and valid (representing what they are ought to represent).

There are also a number of conceptual and technical issues related to anthropometry as a method of nutritional assessment (Gray *et al.*, 1980; Gorstein *et al.*, 1994), including: the appropriate selection (Cole, 1985; Bairagi, 1987; Keller, 1990); classification (McLaren and Read, 1972; Wright *et al.*, 1994) and biological interpretation of anthropometric measures (WHO, 1983, 1995; Briend *et al.*, 1986, 1987; Dibley, *et al.*, 1987; Smith and Booth, 1989; Ruel *et al.*, 1994; Victora, 1994; Roy, 2000; Martorell, 2001); the importance of accurate of age estimates (WHO, 1986; Bairagi, 1986; Katz, 1989; Beaton *et al.*, 1990; Pelletier, 1991; Oshaug, 1994; Gorstein, *et al.*, 1994; WHO, 1995) and anthropometric measures (Kostermans, 1994; MacFarlane, 1995*a*); the validity of anthropometric indicators (Sauerborn *et al.*, 1992), to predict subsequent mortality (Smedman *et al.*, 1987), association with biochemical measures (Trowbridge, 1979); the use of international growth reference data (Geissler and Miller, 1985; Kow *et al.*, 1991; Sheard, 1991; Gopalan, 1992; Piwoz *et. al.,* 1992; Gorstein, *et al.*, 1994; MacFarlane, 1995*b*); the use and availability of anthropometry software (Sullivan *et al.*, 1990) the presentation of anthropometric data (Waterlow *et al.*, 1977; Krick, 1986; Mora, 1989); and the selection of who should be measured and why (Kelly, 1992; Pelletier, 1991).

Biological interpretation of anthropometric indices: Weight, height and mid-upper arm circumference (MUAC) are the most commonly collected anthropometric measures used to assess nutritional status at the population level. Height and weight based indices reflect and discriminate between different physiological and biological processes (WHO, 1986). Weight is highly sensitive to recent short-term epidemics or seasonal food fluctuations (WHO, 1986). Height measures the cumulative deficit in growth associated with long term factors such as chronic dietary inadequacy, frequent infection, poor feeding practices and poor environmental conditions (Solomons *et al.*, 1993). Height is used to monitor socio-economic development and well-being as it is highly correlated with *per capita* income and environmental conditions (Villermé, 1929; Tanner, 1982; Steckel, 1983; Gopalan, 1992; WHO, 1995).

Height is deemed a more reliable indicator of substandard function and past malnutrition which have involved a considerable cost to society (Gopalan, 1992). Fundamentally, to be small in stature means, *ceteris paribus*, to be less powerful physically than if one were taller. The costs of being small, and of becoming, small are fundamental issues surrounding the functional implications of individual adaptation to nutritional constraint and the paradigm of genetic potential. From a ecological perspective smallness has advantages (Goldstein and Tanner, 1980). A small body enables a person to survive and to sustain a level of activity in a world of nutritional contraint, because a smaller body requires less energy. Seckler (1980) extends this point stating that a small body can also avoid all kinds of functional disabilities, coining the phrase 'small but healthy'. Beaton (1989) argues while there is nothing wrong with *being* small, the process of *becoming* small is damaging (Beaton, 1989). Empirical evidence has accumulated to demonstrate the advantages of small size should not be considered cost free. The functional implications of growth retardation are not only lifelong with an increased risk of morbidity and mortality (Pelletier, 1993), reduced physical and mental capacity but also inter-generational, small mothers are at higher risk of bearing low birth weight babies (Pollitt, 2000).

Recently, stunting has also been associated with overweight within countries undergoing nutrition transition (Popkin *et al.*, 1996). It is possible that linkages between stunting and obesity are biological in origin. Barker (1992, 1994) suggests that an infant's major adaptation to undernutrition is a reduced growth rate and related changes in foetal hormone production that yield long-term effects including changes in insulin and growth hormone. Barker (1992) has also found in a series of studies on small samples of English adults that low birth weight was related to subsequent abdominal obesity and a wide range of hormonal changes, associated with syndrome X. Another empirical study provided preliminary evidence that stunted children tended to overeat opportunistically (Hoffman, *et al.*, 2000). Although, the underlying mechanisms remain under discussion, this association has serious public health implications particularly for lower income countries which have high levels of undernourishment and limited resources.

Use and selection of growth reference data: To be able to assess and evaluate the observed weight, height and MUAC measures comparisons are made with distributions of the same measurement at the same age in a presumably healthy well-nourished reference population. The use and selection of the most appropriate growth reference data-set is also an area of contentious debate (MacFarlane, 1995*b*). Conceptually, many researchers (Cameron, 1986; Delport *et al.*, 1997) have stressed the importance of distinguishing between the concept of a 'reference' and that of a 'standard' or 'target'. It is important that the all growth references are used and described as 'references' instead of 'standards'. These charts were designed as references for comparative purposes and recommended for use with samples or groups (WHO, 1994).

The discussions surrounding the use of international, national or local references for the assessment of human growth, have focused on whether such references should reflect 'actual' growth or 'potential' growth (Tanner and Goldstein, 1980; Cameron, 1986). Conceptually the appropriateness of comparing observed anthropometric measures to international growth references pivots around the relative contribution of genetic inheritance and environment influences on body size. There are contrasting views regarding the influence of genetics. Steckel (1995) states 'genes are important determinants of individual height, but genetic differences approximately cancel out in comparisons of averages across most populations'. The averaging-out of genetic influence is particularly true of child populations. Much evidence indicates that differences in the impact of genetic endowment on growth that are associated with ethnic growth are manifested only in adolescence (WHO, 1995). The global analysis of genetic variation collected by Eveleth and Tanner (1976) clearly suggested that there was considerable variation in growth and body proportions amongst different ethnic groups. One of the main advocates of 'genetic theory' is Floud (1986) who disputes the environmental argument on the basis that there is a lack of a credible scientific model on the causation of growth. Stature variation is considered highly heritable-heritability co-efficient estimates range from 56-66% (Mueller, 1976; Roberts *et al.*, 1978). Matorell (1989) reviewed an extensive number of empirical studies conducted world-wide and concluded that genetics plays a minimal role in growth retardation Comparative growth patterns of children from the same ethnic group but different socio-economic backgrounds within the same country and secular increases in height all provide convincing evidence that environmental factors such as food consumption patterns, illness and access to sanitation and potable water are the main contributory factors of poor growth (Habicht *et al.*, 1974; Matorell, 1989). However, the implications of the choice of growth reference for assessing the nutritional situation are not trivial since different anthropometric standards can yield very different estimates of malnourishment (Millman *et al.*, 1991).

WHO (1986, 1995) currently recommends that observed weight and height measures should be compared to the National Centre of Health Statistics, Centre for Disease Control/World Health Organisation (NCHS CDC/WHO) growth reference data. The use of the NCHS/CDC growth curves as the main international reference has be questioned. The growth reference curves formulated in data 1975 were actually derived from four different data-sets: FELS-longitudinal study and three NCHS cross-sectional surveys. These data-sets have a number of critical differences. Stature (linear growth) was measured differently in the two populations; on average recumbent lengths are greater than standing height by approximately 0.5 cm. The sample populations and the study design differ: the FELS data were collected from white middle-class children and followed longitudinally. The NCHS data were derived from cross sectional surveys representative of all U.S. child population ethnically and socioeconomically. The FELS children were generally taller and thinner than the NCHS children, differences which are attributed to the sample characteristics, study designs and the distinctive growth patterns of breast-fed and formula fed infants (Agostoni *et al.*, 1999). Subsequently, when using the two data-sets for comparative purposes a general improvement in HAZ and WHZ and deterioration of WAZ at 2 years of age is often observed, this is partially attributed to the disjunction between the two growth reference curves. The differences in the study design also mean that the NCHS data which was collected cross-sectionally relates to absolute or distance values and is inappropriate to estimate individual rates of growth as velocity (McMurray, 1996). A number of researchers (Dettwyler and Fishman, 1992; Gorstein *et al.*, 1994; WHO 1994) have highlighted the importance of recognising these inherent differences when interpreting anthropometric indices and the inadequacy of the NCHS reference data for the first 2 years of life. Presently, to overcome this it is advocated that anthropometric data for population studies be presented by age groups (WHO 1977, 1986, 1995).

The inherent problems associated with the NCHS international growth reference has led the WHO establishing a protocol for an international growth study in which participating mothers will exclusively breast-feed their offspring for 4-6 months, in accordance with WHO recommendations. The data resulting from these studies will be used to create truly 'international' growth references free from the current inadequacies of the NCHS charts (Cameron, 1997).

Analysis of anthropometric data: Several systems using anthropometric data have been devised to classify individuals as 'at risk'. In the past, three classification systems using anthropometry have been widely used Gómez *et al.*, (1956) Wellcome (1970) and Waterlow (1972, 1973). Each system specifies the severity and type of malnutrition. All utilise at least one anthropometric index and one or more reference limit from recommended reference data. It should be noted that the numerical cut-off points of -1, -2 and -3 standard deviations below the reference median to represent mild, moderate and severe height and weight deficits used in these classification systems have been devised on the basis of 'normal' Gaussian distribution curve. They do not relate to specific short or long term risks (WHO, 1995). The performance of an indicator is one that reflects the issue of concern or predicts a particular outcome. The methodology for choosing appropriate indicators and cut-offs focuses on future risks to health. The performance of an indicator is based on its *sensitivity* (i.e. its ability to detect the presence of a condition or disease and its *specificity* (i.e. its ability to indicate the absence of a condition or disease) in monitoring or predicting situations (Habicht, 1980; Habicht *et al.*, 1982).

Selection of sensitive index group to monitor nutritional status: All things being equal the anthropometric status of any sub-group can be assessed and monitored to serve as an indicator of the community's access to food, health and care as long as that subgroup's anthropometric status is responsive to changes in the food, health and care system (Pelletier, 1991; Kelly, 1992). Presently, pre-school children are the most common index age group used to evaluate and monitor community nutritional status. The frequent use of pre-school children is due in part to the institutionalisation of growth monitoring (Lotfi, 1988; Taylor, 1989; Mock, *et al.*, 1993). In some developing countries the pre-school weight for age (WA) clinic data is the only of source of nutrition information available. The main advantages and reasons for using routinely reported clinic data as a part of a nutritional surveillance system is its low cost and timeliness as well as its unique nature in providing national coverage (with potential for highly disaggregated analysis) over extensive time-series. These qualities do not exist within one-off cross-sectional nutrition and health surveys.

The use of routine growth monitoring data also has its limitations. The quality of the decisions based on a nutritional surveillance system are closely related to the accuracy, reliability and representativeness of the clinic based data of the community or target population (Serdula *et al.*, 1987). The validity of the clinic-based data has received little attention. This is partly due to the lack of independent probability samples, representative of the population being available for direct comparison. Surveillance literature on the validity of data used within systems is still sparse for this reason. The few evaluation studies which have been published compare the prevalence rates of malnutrition reported by the clinics to those generated by independent samples for the same time period and geographical area (UNICEF/CORNELL, 1984; Serdula *et al.*, 1987; Grosh *et al.*, 1990; Pelletier and Johnson, 1994). The overall prevalence reported by clinics compared to survey data were reasonable close in absolute terms in Botswana (UNICEF, 1983), Swaziland (Serdula, 1987) and Jamaica (Grosh, 1990). In El Salvador they were over-estimated (Trowbridge, 1980) and in Malawi they were under-estimated (Serdula, 1987). These studies provide supporting evidence for the need to evaluate the quality and representativeness of clinic data. This type of evaluation will assist in determining the usefulness and establishing the limitations of the clinic data for decision-making (Serdula, 1987).

The overall conclusion of these studies is that caution must be used when extrapolating the findings from the surveillance information to the general population and in the use of such data for programme planning due to inherent bias. A number of errors and biases may occur during the generation of clinic data. Pelletier *et al.*, (1994) suggested that two types of error may affect the validity of clinic based data. The first set is related to the inaccuracies or incompleteness in collecting, reporting and analysing the data. The second set is related to attendance bias. The pre-school children who attend growth monitoring represent only a fraction of children in the catchment area and are probably not representative of all children in the community.

The traditional focus on pre-school children is based on the assumption that this age group is at greatest nutritional risk and consequently the most responsive to and at risk of changes within the food and health system within the household. This supposition is supported physiologically and empirically (Levinson, 1991; Engle *et al.*, 1996) The very young are less able to cope physiologically with nutritional deficiencies than older children and adults. In addition, pre-school children who are nutritionally deprived during their first years of life, subsequently suffer poor growth and have only a limited capacity to recover. Empirically pre-schooler's account for a disproportionately large share of morbidity and mortality in most developing countries. In sub-Saharan Africa on average more than 20% do not reach their fifth birthday. Nutritional deprivation is either directly or indirectly associated with most of those deaths (Vella *et al.*, 1994). For these reasons there has been strong support for monitoring the growth patterns of pre-school children and relatively more research has focused on the determinants of the nutrition status of this age group than others within the household.

Recently, the universal acceptance of the sole use of pre-school children as the most sensitive age group has been challenged. As Rivers (1988) points out, 'physiological vulnerability' is modified by social factors which can totally reverse expected effects. Using pre-school anthropometry to target nutritionally insecure households assumes that there is a positive direct correlation between the nutritional status of this age group and older household members. That is, the nutritional status of older household members is reflected in that of young children. Nutritional science literature emphasises the use of anthropometry for one child to infer something about the household environment that may affect others in the household including 'a sibling yet to be born' (Beaton *et al.*, 1990).

However, pre-schooler's may not be the only sensitive index group to change in food and health resources. Other members upon whom the pre-schooler's are ultimately dependent for survival may suffer more (Dreze and Sen, 1989). A common compensatory mechanism for a reduced energy intake is the reduction in energy expenditure through decreased physical activity. Since, pre-schooler's do not contribute to the household livelihood system they actually have more scope to compensate by reduced activity compared to adult income earners and carers. Consequently, pre-schooler's may be less sensitive to reduced energy intake in a food insecure situation whereas adults have to maintain a constant energy expenditure to ensure the continual functioning of the household (Pelletier, *et al.*, 1991; Kelly, 1992).

Moreover, the sole use of under five anthropometry assumes the socio-economic factors which are statistically associated with pre-school nutritional status are also similar to those associated with the nutritional status of older household members (Pelletier, *et al.*, 1991). Child PEM may be a sensitive measure of living conditions but anthropometry in general and poor child growth in particular lacks specificity. The existence of child PEM in a population signals that some aspect(s) of living conditions are sub-optimal but without additional information it is not possible to specify which are main causes. In an effort to improve specificity the prevalence of child PEM is often disaggregated by various socio-economic and environmental characteristics in order to identify those strata in society most affected and obtain some indication of the underlying processes responses for elevated prevalence (Haaga, 1986). Socio-economic factors and household characteristics associated with pre-school malnutrition are often used when designing policies and targeting interventions to improve household nutritional status. However, the utility of this approach is more often assumed than tested (Pelletier, *et al.*, 1991; DeRose, *et al.*, 1998)

The socio-economic factors associated with malnourished pre-schooler's may not be the same as those linked with other age groups who are malnourished. This can be partially explained by the age-specific nature of malnutrition (Glick and Sahn, 1995; Grosse, 1996; Sahn and Alderman 1997). Theoretically the social, economic and biological roles, opportunities and constraints which affect nutritional status through dietary intake, nutrient requirement and exposure to disease differ by age and gender (Pelletier, *et al.*, 1991). Hence, targeting and devising interventions using age-based indices may only improve the nutritional status of the target group not other age groups within the household.

The use of pre-schooler anthropometry as a proxy of household food security and nutrition disregards the multi-factorial nature of nutritional status and the influence of other factors relating to disease and maternal care that can also affect child growth. The sole use of the anthropometric status of pre-schoolers makes it difficult to discriminate between the various determinants of malnutrition and subsequently select appropriate interventions. One of the major limitations of anthropometry is its unspecific nature, to accurately interpret inadequate weight for height measures or poor growth it is necessary to simultaneously collect information pertaining to the prevailing ecological conditions including both food and health status data to accurately understand manifestation of poor growth.

Technically pre-school anthropometry is particularly prone to errors (Gibson, 1999). Recumberant length are difficult to estimate precisely as is age due to the lack of institutionalised registering of births in rural communities. In recognition of the limitations of pre-school anthropometry research efforts have begun to focus on other age groups who may be a more sensitive barometer of community nutritional status and easier to measure.

The increase in the availability of data on the nutritional status of school-aged children provides empirical evidence that malnutrition is widespread amongst this age group and these nutritional problems adversely affect school attendance, performance and learning (ACC/SCN, 2000). Large height censuses carried out since 1979 amongst the school aged population in Latin America and Caribbean suggest that between a third to half are stunted. These prevalence rates of stunting in school children are comparable to the results generated from the five-country analysis by the Partnership for Child Development carried in Africa and Asia, illustrating the immense problem of stunting and its persistence throughout childhood. (PCD, 1998; Florentina *et al.*, 2002; Soekirman, *et al.*, 2000; Tee *et al.*, 2002).

The physical growth of school children aged 5-9 years is the result of both environmental and genetic factors and the interaction between these factors. Linear growth retardation is the main problem observed amongst this age group. The potential for catch-up growth among stunted children is thought to be limited after two years of age if children remain in poor environmental conditions (Martorell, *et al.*, 1994). Longitudinal studies show that some catch-up in height between 2-8 years is possible for children who were not born LBW or severely stunted in infancy (Vella *et al.*, 1994; Walker *et al.*, 1996; Adair, 1999), the degree of catch-up is dependent on the timing (Martorell, *et al.*, 1994) duration of the nutritional insult (Golden, 1994).

Stunting at two years regardless of whether catch-up was achieved or not is significantly associated with later deficits in cognitive ability, further emphasising the need to prevent early stunting (Buzina *et al.*, 1989; Pollitt, 1990). The enormous educational and economic gains to be achieved from improving the nutrition and health of school children are gradually being realised. This has led to the development of highly cost-effective programmes designed to achieve these aims, including supplementary school-feeding, mass application of antihelminthics and delivery of micro-nutrients particularly iron and iodine (Levinger, 1989; ACC/SCN, 2000).

Adolescence is a transition phase when children become adults. During adolescence hormonal changes accelerate growth in height. Growth is faster than at any other time in the individual's postnatal life except the first year (Brasel, 1982). Adolescent growth varies significantly world-wide with many of the differences observed according to chronological age attributable to variation in timing of the growth spurt (Eveleth and Tanner, 1990). There is a dearth of detailed methodological work on the specific cut-offs, predictive values, and attributable risks of adolescent anthropometric indices (Salama and Collins, 1999). A review on the assessment of nutritional status in emergency-affected population focused on adolescents and outlined the main complications of using and interpreting anthropometry to diagnose the nutritional status of this age group (Woodruff and Duffield, 2000). These included: changes in body proportions with age (Brasel, 1982), pubertal development and inter-ethnic differences in genetic growth potential.

Adult nutritional status is also a neglected field of study, having received much less attention than that of children, partially because of the higher vulnerability of the growing organism (Young and Jaspers, 1995). This exclusive focus is in part unjustified. Adult undernutrition appears to be increasing (Underwood, 2001) Empirical research has shown that parents often sacrifice their own feeding in times of serious food shortage (acute or chronic) in favour of young children within the family (Robertson and James, 1998). The measurement of adults is advocated on a number of accounts (Ferro-Luzzi and James, 1996; Jaspers and Shoham, 1999). The economic livelihood of populations depends to a large extent on the health and nutrition of adults. Adult nutritional status actually simultaneously represents outcomes and inputs of the food system; being influenced by the household's entitlement to food as well as determining their capacity to work, itself a valuable component of the exchange entitlement. Also, the concurrent measurement of adults and children provides an invaluable opportunity for intra-household analysis this is discussed in more depth below.

Populations are ageing; the 20th century has seen an unprecedented transition from high birth and death rates to low fertility and increased life expectancy. In Western nations the elderly are a group who are considered at increased risk of undernutrition. This may be the result of physical ill health or related to a variety of psychological and social factors. In contrast, the majority of the elderly living in rural subsistent communities in lesser developed countries enter old age after a lifetime of poverty and deprivation, poor access to health care, and an inadequate diet (Solomons, 2000). For the majority of elderly farmers retirement is not an option particularly with rural to urban migration, the lack of pensions, and deaths of younger adults from AIDS, older people are compelled to work and care for orphaned grandchildren. The decrease in social networks in these communities mean that capacity to function independently is essential to ensure a good quality of life (ACC/SCN, 2000). In Zimbabwe a recent study examining the diet and nutritional status of elderly found that dietary patterns, anthropometric measurements and biochemical values were influenced by area of residence, age, income and educational level (Allain *et al.*, 1997).

Intra and inter household analyses of anthropometric status: Dugdale, (1985) suggests that more information can be gained by studying the anthropometric patterns of nutrition and malnutrition within and between families rather than using one index group. It is argued that intra and inter household analyses of anthropometric status can provide a number of specific patterns of malnutrition that can be subsequently interpreted as a result of one or more nutrition problems. Malnutrition and disease tends to cluster in nutritionally vulnerable households. When such households are identified the pattern observed determines the household needs and interventions can be targeted more accurately and efficiently. Differences in nutritional status between members of the same household occur at different times of food surplus and deficit. If similar individuals (i.e. of the same age, gender, status) of households of similar types (same structure, size income group) are found to be nutritionally at risk then it is possible to characterise them and identify them as a vulnerable group to target.

The way in which nutritional status is distributed among household members, particularly children and adults is relevant for a several reasons. First if there is a pattern of intra-household association of undernutrition in any given community then nutritional status of any household member could be used to predict the risk of undernutrition of others. Second, the presence and intensity of the association can clarify the nature of the main determinants of undernutrition in specific communities. It is hypothesised that concurrently monitoring the anthropometric status of both adults and children within the same household can assist in distinguishing between primary malnutrition (food insecurity) and secondary malnutrition (infection and disease) in children. This approach is based on the assumption that the co-existence of child and adult malnutrition in the same household indicates shortage of food and the household is subsequently diagnosed with primary malnutrition. In situations where child malnutrition occurs in higher proportions than chronic energy deficiency in adults it is assumed that the child is probably suffering from secondary malnutrition due to disease rather than food availability (James *et al.,* 1993). Patterns of household association of under and over-nutrition can also be used as a marker of the stage of nutrition transition in a given society (Monterio, *et al*., 1997; Doak, *et al*., 2000).

Given the benefits associated with intra-household analyses of anthropometric status there is a remarkable scarcity of studies addressing the patterns of intra-familiar association of undernutrition. Very few studies have attempted to quantify or systematically study patterns in specific populations. A number of issues may have hampered research in this area. Firstly, nutritional surveys in the past have been restricted to one age group, generally pre-school children. Secondly, conventional child anthropometric indicators are not directly comparable in terms of their specificity. Recently a number of studies have endeavoured to overcome the dearth of data and have proposed comparable nutritional indicators and statistical methods to identify patterns of intra-familiar association (Pelletier, *et al.*, 1991; Ferro-Luzzi, *et al.*, 1993; Monterio, *et al.*, 1997).

2.4 Review of Conceptual Models of Nutritional Status and Risk

The aim of a conceptual model is to improve explanatory power so that *informed decisions for policy development and programme planning*[1] can be made on the basis of the implications of the model (Mclean, 1984). In 1980 an analysis of available nutrition conceptual frameworks was made by the World Hunger Programme (WHP). It was concluded that a causality framework should show a hierarchy of causes of malnutrition, be multi-sectoral but reducible, facilitate interdisciplinary dialogue and facilitate training and mobilisation (Jonsson, 1997).

The main aim of those working within the sphere of nutrition security is to identify the origins of nutritional risk to reduce its occurrence and ultimately prevent malnutrition. The approach used to identify risk depends upon the perception of the origins of the risk. The review by Mclean (1984) of various conceptual models and technical approaches used to identify the determinants of nutritional risk suggested that there were three approaches, traditional, current and developing.

During the last two decades there has been gradual shift in emphasis in the study of nutritional risk from the traditional physiological approach which focused on the individual to a broader household approach which simultaneously examines the interrelationships between people and resources (Mclean, 1984). This broader perception of nutritional risk has continued during the intervening years since Mclean's publication. Sen's (1981) construct of entitlements dominates many food and nutrition security frameworks. Using this broader approach, conceptual models of determinants of malnutrition developed by Economists (Taylor, 1978; Chernichovsky

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[1]Own words added in italics

and Zangwill, 1990;), Agriculturists (Omawale, 1980; Viteri *et al.,* 1981; Spurr, 1984; Pacey and Payne, 1985; Payne, 1987) Epidemiologists (Tomkins and Waston, 1989) and International organisations within United Nations system (UNICEF, 1990 and ACC/SCN, 2000) have been utilised, modified and combined to reflect the nature and manifestation of the specific nutrition problem being studied (Ruel *et al.*, 1996).

Some of the conceptual linkages between nutritional risk and outcome have been extensively studied, are well explained and internationally accepted as theory, law or conventional wisdom (Timmer *et al.*, 1983). For example, the linkage between malnutrition and infection is well established since the landmark publication "Interactions of Nutrition and Infection" by Scrimshaw *et al.,* (1968). Similarly, the link between income flows and household consumption patterns is accepted and has been quantified by *Engel's Law* and *Bennett's law* (Taylor, 1978). While other linkages between nutrition and intra-household allocation of resources have until recently remained virtually untouched (Haddad, *et al.*, 1997).

A web of linkages encompassing a wide range of food, health, demographic, social and economic risk factors that operate at the individual, household and community level have been identified in previous empirical work examining the determinants of chronic energy malnutrition within subsistent agricultural communities.

Individual level - Nutritional risk factors: The traditional approach used to identify nutritional risk focused on the individual as the primary unit of observation. This approach concentrates on the nutritional status of pre-school children or other physiologically vulnerable segment of the population. Age and gender are two individual level characteristics that are ascribed at birth, not amenable to change and are considered integral in the analysis of the pattern of malnutrition. Dietary intake, nutrient requirement and exposure to disease differ by age and gender determined by biological, social and economic roles, opportunities and constraints (Pelletier, *et al.*, 1991).

The importance of age-specific effects has been highlighted by a number of studies showing that impact of education and income differ by age group (Glick and Sahn, 1995; Grosse, 1996). Failure to account for cohort-specific differences can lead to erroneous impact analysis and imprecise targeting mechanisms (Sahen and Alderman, 1997). Similarly, the association between gender and nutritional status is seemingly simple in theory but more complicated to interpret in practice. From a biological perspective males and females of the same age, height and weight vary physiologically, in size, composition (amount of fat to fat free mass) and reproductive state. Cultural factors can impinge on the relationship between gender and nutrition via determining the allocation of resources. Since, gender biases are predominantly culturally determined they differ within and between countries. Empirical studies conducted in Asia have highlighted how girls and women are discriminated in terms of the amount and type of food consumed. A review of research conducted within Africa revealed no gender bias in the allocation of resources (Svedberg, 1990). In Zimbabwe female children and adults are responsibility for food preparation and cooking suggesting that they may have increased access. In addition, social pressures can also indirectly affect nutritional status by asserting a strong influence on body image. In Zimbabwe being large (fat) is considered wealthy, beautiful and powerful; this situation is not dissimilar to the Northern hemisphere where women are preoccupied with being slim.

Place of birth (Alderman and Garcia, 1994), birth order (Vella *et al.*, 1995; Horton, 1988; Moffat, 1998), breast-feeding (Chandra, 1979; Soysa, 1981; Akre, 2000) weaning patterns and feeding practices (Nestel, *et al.*, 1992; Alderman and Garcia, 1994), number of times fed (Ritchie, 1986), immunisation status (Mbago, *et al.,* 1992), attendance to growth monitoring programmes have all been highlighted as important determinants of pre-school nutrition. Research has shown that higher birth order children suffer due to increased strain on family resources in terms of food and health-care. In the Philippines, it was found that the adverse effects of birth order were substantially greater on height than on current weight deficits (Horton, 1988). Weaning patterns including age solid food is introduced, the type of weaning foods used and the interaction between the preparation of weaning foods in unsanitary conditions, nutritional status and subsequent morbidity and mortality have been extensively studied (Underwood, 1985; Hendricks, *et al.*, 1992).

Models associated with this "traditional" individual level approach generally take the theme of a "vicious circle", emphasising an internal cycle of deprivation which eventually results in diminished human capital (ACC/SCN, 2000). The classical model of malnutrition-infection cycle is one that is well documented (Mata, *et al.*, 1971, 1972, 1979; Cole and Parkin, 1977, Rowland *et al.*, 1977; Nabarro *et al.*, 1988; Walker *et al.*, 1992; Vella *et al.*, 1995). The principle underlying malnutrition and infection is physiologically synergistic and cyclical. It has been shown in children there is a problem of circularity (endogeneity) in causation (Garcia and Alderman, 1989), that low weights can cause illness, and that illness episodes can cause low weights. More recently, Pelletier *et al.*, (1993) have highlighted that epidemiological evidence suggests that malnutrition and infection have a multiplicative effect on mortality rates, rather than the additive relationship implicitly assumed (Chen *et al.*, 1980.

The type of illness, its duration and severity can independently affect nutritional status. Some infections are more strongly associated with poor growth than others. Seasonal occurrence of diarrhoea, respiratory infections, measles and malaria are the major infectious diseases implicated with poor nutritional status (Rowland, *et al.*, 1977; Tomkins and Watson, 1989). The results generated from empirical studies conducted in Zimbabwe, provide contrasting evidence in relation to the impact of diarrhoeal disease on pre-school child growth. Moy *et al.*, (1994) suggest that recurrent diarrhoea was not a potent cause of growth faltering in early childhood except in a small minority of largely catastrophic cases.

Illness can also have indirect impact on the household's nutritional status. The sickness of an adult carer or income earner can indirectly effect the nutritional status of dependants through the loss of earning or caring capacity. Illness can be the pivotal event which impoverishes poor households further since the main asset to most subsistent agriculturists is their bodies (Chambers, 1989).

Household level - Nutritional risk factors: Households attributes are often used to develop a series of risk characteristics which are in turn used as targeting mechanisms. Household characteristics such composition (age and gender), stage of household within the life-cycle, dependency ratio, size, gender, education level and main occupation of the household head, socio-economic status are all considered important mediating factors in the acquisition of nutrition at the household level (Taylor, 1978; Chernichovsky and Zangwill, 1990). Household behaviour, particularly its decision-making and choices over the allocation of resources can ultimately intervene between prevailing market forces, food, health and environmental conditions or policy interventions to determine the nutritional status of its members. Positive deviance or nutritional resilience within a hostile environment is largely attributed to household behaviour (Zeitlin, 1991).

The age and education level of household head or adult carer can indirectly determine the nutritional status of dependants through a number of routes. Knowledge can affect behaviour and practices by influencing their lifestyle and social networks; higher qualifications are directly associated to better paid occupations and income and are often used as a proxy measure of socio-economic status. In Zimbabwe, researchers have shown a positive correlation between the level of parental education and child nutrient intake and health status (Sanders, 1982; Maszur and Mazar and Sanders, 1988; Senauer and Garcia, 1991; Behrman, 1995). Contrary to previous empirical findings the most recent ZDHS (1994) suggested that women need at least a secondary level of education before a significant effect was observed on child nutritional status. The association between relative risk of stunting and paternal educational level was more pronounced than the level of maternal education. Whereas a positive relationship was observed between mother's educational level and utilisation of preventive health-care (CSO, 1995). Education was an important determinant of adult nutritional status. Women with secondary education were 40% less likely to suffer from CED compared with women with primary school education.

At the other end of the spectrum women with secondary education were 30% more likely to be overweight; this finding may reflect the change in lifestyle and eating patterns associated in higher educated women that have increased earning capacity. Empirical research has also shown that older parents have a positive impact on child height (Horton, 1988; Senauer, *et al.*, 1991; Armar-Klemesu, *et al.*, 2000).

Gender analysis at the household level has illustrated the importance of considering who is responsible for decisions related to allocation of resources. The relationship between child nutritional status and gender of the household head is inconsistent. Recent empirical work has suggested that female-headed households have better nutritional status as they control and prioritise the household resources differently to male headed households (Handa, 1994; Kennedy and Haddad, 1994). However, children residing in *de facto* female headed households may also be disadvantaged by the lack of time available for food preparation and child-care due to higher dependency ratios (Mazur and Sanders, 1988). The impact of these conflicting demands on women's time are dependent on her position or control over resources within the household (Hindin, 2000).

The dependency ratio (number of dependants to number of potential income earners) has been shown to be highly correlated with child nutritional status. In Zimbabwe, Mazar and Sanders (1988) found that higher levels of malnutrition existed within households with a high dependency ratio. In Ethiopia households with higher dependency ratios responded less well to seasonal food shortages (Ferro-Luzzi, *et al.*, 1993). Household size is a factor through a dilution effect where larger households reduce the amount of resources (time, energy, money) available for each child, thus hindering social and physical development. Kucera and McIntosh, (1991) found that even after controlling for age, sex, ethnicity, family income and maternal education there was a significant inverse linear effect between child nutritional status and household size with children residing in large families (> 6 children) being more at risk than those living in intermediate households (4-5 children) and children residing in small households (1-3 children) being least at risk.

Housing characteristics including availability, access and utilisation of potable water, sanitation housing structure, are important environmental risk factors that can increase exposure to disease (Burger and Esrey, 1991). A review of studies examining the association between water, sanitation and nutritional status concluded that distance to water source governed the amount of water used and the frequency it was collected. This indirectly affected the level of pathogens and exposure to disease (Esrey and Habict, 1986). Water quality, not only the access but utilisation of sanitation were also important risk factors (VanDerslice, *et al.*, 1994).

The food and nutritional security conceptual frameworks that have evolved during the last two decades have substantially contributed to rationalising the linkages between food availability, access and utilisation and nutritional status (Maxwell, 1999; Terra de Souza, 1999). Traditionally household consumption units were directly related to the amount of land available or kilocalories. These correlates were then subsequently used to distinguish between the food secure and the nutritionally at-risk. Presently, a broader conceptual approach is advocated which include various aspects of the food economy including sources of food, cash income, informal mechanisms by which food is obtained and the type and extent of buffers or its resilience to poor availability such as food stocks, wild foods and livestock holdings and domestic or agricultural assets (Maxwell and Frankenberger, 1992; Boudreau, 1998; Maxwell, 1999).

The food security conceptual models have highlighted the importance of obtaining a range of socio-economic variables which capture present and future level of the household's vulnerability to food and nutrition insecurity. The relationship between the level of welfare or degree of 'poverty' and its association with health and nutrition has been observed for over a century (Reutlinger and Selowsky, 1976; Liberatos, 1988; ACC/SCN, 1997; Dowler and Pryer, 1999). The inverse relationship between poverty and malnutrition are well documented. The poor are more likely to be food and health insecure and experience higher rates of malnutrition (Becker, *et al.*, 1986; Quinn *et al.*, 1995). Over 80% of the literature on the determinants of adult and child malnutrition in developing countries incorporate a measure of household welfare. Poverty is a multi-dimensional construct which is predominantly socially defined. In practice, the measure of poverty is fraught with technical difficulties. An array of indicators exist, each measuring slightly different dimensions of welfare; these measures can lead to different classifications of the extent and severity of poverty within an area, subsequently leading to the identification and selection of different population groups (Glewwe and Van Der Gaag, 1990). Common welfare indicators include: *per capita* kilocalories, proportion of household expenditure spent on food (food ratio), education level of household head or mean education level of all adult household members, agricultural land *per capita*, type of housing, number of assets.

Nutritional risk - community level: The major alternative approach to the individual and household level approach used to identify the origins of nutritional risk is the community level. Generally communities are identified and targeted on a geographical basis using indicators such as agro-ecological zones considered climatically or environmental at-risk. Addo *et al.*, 1988 studied Nigerian school children and illustrated how nutritional status was related to five different ecological zones; the growth rate was related to the different ecology which determined food supplies. However, other studies have demonstrated how assumptions related agro-ecological zone need verification. A study carried in Kenya demonstrated how the heterogeneity in land quality determined cropping patterns. This led to more drought tolerant crops being grown in areas of high climatic risk ensuring a subsistent food supply whereas areas with relatively better soil quality grew hybrid maize and had subsequently lower yields and significantly higher levels of malnutrition (Haaga, *et al.*, 1986).

Lastly, the *nutrition throughout the life cycle* conceptual framework recently introduced by WHO (ACC/SCN, 2000) explicitly illustrating how malnourishment can be perpetuated inter-generationally and highlighting how malnutrition can affect all age groups across the entire lifespan. The life cycle approach clearly outlines the extent of the Nutrition Challenges of the 21st Century at individual, household, community, national and global level.

CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter which details the research methodology is divided into three sections. The first section provides an overview of the conceptual framework, the second section details the analytical framework and the third section the empirical framework.

The secondary and household level data-sets elaborated and analysed within this thesis were originally obtained as part of a European Union funded research project 'An Integrated Model of the Food System in a Region of Zimbabwe' (hereafter referred to as the IMFSZ). The Science and Technology for Developing Countries Research Project (TS3*-CT92-0048) was co-ordinated by the University of Edinburgh who collaborated with the University of Zimbabwe and the National Institute of Nutrition in Rome (INN). The main aim of the IMFSZ study was to construct an integrated model of the food and health system which could be used to predict the impact of any changes within the system on the nutritional status of the rural population at district level. The unique feature of this model was its sole reliance on routinely collected secondary data to identify and predict situations of food and nutrition security and to provide insights into the underlying causes of its observed distribution.

An essential component of the IMFSZ study was the verification, validation and enhancement of the secondary data-sets. A primary household level study was undertaken to assess the accuracy of the secondary data-sets. The author was employed by the project to work as part of a multi-displinary team to develop, implement and supervise the secondary and household survey data collection in Zimbabwe. The respective responsibilities of each team member who undertook the data collection are indicated and acknowledged where appropriate within the text.

3.2 Conceptual Framework

As a theoretically premise the nutrition situation within Buhera District was investigated using an adaptation of the conceptual framework introduced by UNICEF

1990 advocated by the African Regional Nutrition Strategy (1993-2003) for assessment, analysis and action of nutrition problems. The UNICEF conceptual framework has been endorsed by many others (Pinstrup-Andersen *et al.* 1993; Gross and Schultink 1999) for the identification of main determinants of human nutritional status. The hierarchical nature of the UNICEF conceptual framework illustrates how factors at various levels or domains such as the human body, household, community inter-link and the resultant relationships impact on nutritional status. An underlying premise of this conceptual framework are the proximate factors: dietary intake and health status. The cyclical synergistic relationship between diet and disease is complex, but it is well recognised that both diet and the absence of disease are essential for adequate growth and to maintain body composition. Individual characteristics such as age, gender, size, health status and physical activity levels ultimately determine energy and nutrient requirements.

Decisions related to resource allocation and behavioural determinants that affect the level of food security, the degree of exposure to infections through the prevailing environmental conditions, and type of child care practices are all mediated at the *household level*. These underlying or distal *household level* factors directly affect the immediate causes that ultimately impact on nutritional status at the *individual level*. At the *community level*, poverty and access to education and primary health care are cited as basic causes and main limiting factors of nutritional status.

Figure 3.1 illustrates a modification of the UNICEF conceptual model used in the Buhera study. The specific issue being investigated within this thesis, the production of child and adult nutritional status as measured by standardised weights and heights is considered to be a process that is seasonally influenced by two immediate or proximate factors at the individual level: dietary intake and (absence of) infection. The underlying or distal factors mediated at the household level include three main components: availability and access to household food security, care practices, formal health-care and environmental conditions. The linkages between these three components and household demography, food production, socio-economic status and welfare to be explored in this thesis are explicitly depicted. At the community level, agro-ecological zone, availability of primary health-care, education, and markets and potable water are considered to influence the households access to food, health-care and a healthy environment. Each of the constructs outlined within the conceptual model are represented by a set of dependent and independent variables that are subsequently used to identify the data requirements. The conceptual framework reflects the series of inferences presented in the introduction; the linkages illustrate the multi-dimensional and interrelated nature of the factors considered to affect nutritional status within subsistent agricultural households in Buhera.

3.3 Empirical Framework

3.3.1 Study design: The comprehensive longitudinal food, health and anthropometric survey of 354 households was conducted over a 15 month period between Oct-94 to Nov-95. The household study used multiple-visit surveys to determine the seasonal variability in the availability and access to food, care, exposure to disease, household size and composition. Three rounds of food consumption, health status (morbidity) and anthropometric data were concurrently collected at 4-monthly intervals during the agricultural year enabling cross-sectional and longitudinal analysis of the impact of seasonal changes in the food and health system on household nutritional status. In addition, alternating rounds of demographic, socio-economic and crop production surveys were administered to capture the seasonal fluctuations of household size and composition, income sources and food stores. To assess both the seasonal dynamics of the nutrition situation and intra-household nutritional status, all household members were also measured. The anthropometric indices generated from the anthropometric measures were used as proxies of child and adult nutritional status. To identify the main factors associated with nutritional status a set of simple indicators used as proxies for dietary intake, health status, care, household demography, socio-economic status and welfare were estimated from data generated from the questionnaires. These were subsequently equated with anthropometric indices.

3.3.2 Criterion used to select the study area and population: The IMFSZ study was conducted to investigate the impact of the seasonal changes in the food and health system on the nutritional status of the population. Resource constraints limited the study to one district. With assistance from the Department of Agricultural Economics at the University of Zimbabwe, Buhera District was selected as an appropriate survey site fulfilling the following study criterion; i) an uni-modal climate, ii) the existence of a settled community dependent on a single agricultural harvest for own direct consumption and/or as fodder for their livestock; ii) the existence of nutritional marginality i.e. a food deficit area, prone to drought as documented by high prevalence rates of malnutrition and dependence on food aid; iii) within easy logistical reach from Harare (245 km) and Mutare (132 km) the two main bases of the survey team.

Buhera District located 245 km South-East of Harare, is some 10,000 sq. kilometers in extent, with a Censored population of 204, 000 (CSO, 1992) see Map 3.1. Buhera District was formerly Tribal Trust Land, renamed in 1981 as the Save Communal Area. Communal areas bestow individual rights to plots for houses, gardens and fields with shared unlimited access to grazing land. Traditionally all married male members of a community have the right of access to arable plots. At the time of the survey the right of allocation rested with local government authorities although in practice they are administered under a mixture of customary and stated defined tenure systems (Cheater, 1990, Tshuma, 1997). Once allocated these land plots cannot be reallocated and the property rights remain with the family. The cultivator however, does not have full rights of ownership; they cannot sell the land, nor may the usufractural rights be sold. As land becomes increasingly scarce, an informal market for unusfractural rights appears to be developing in some areas. On average the communal land holding consists of 2 hectares of arable, half hectare for the homestead and less than 15 hectares of grazing area.

Seventy-five percent of the rural Zimbabwean population resides in the Communal Area (CA). The Save Communal Area in Buhera District typifies CA. In 1992 the Population Census classified the whole of Buhera District as rural. The majority of agricultural households residing in Buhera are small-holders who produce for subsistence and the market. The total enumerated population of Buhera in 1992 was 203,739. Combined with the total area of the district 5,369.23 square kilometres (Surveyor General) the computed population density of 37.95 per square kilometre is much higher than the national rural average of 26.6 indicating possible land scarcity.

Seventy percent of the Communal Areas are located in the least productive areas. Yields vary tremendously by agro-ecological region. Zimbabwe uses a five category land classification based on average annual rainfall, soil type and other climatic factors. This agro-ecological zoning system was matched to the crude Index of Agro-Climatic Seasonality (IACS) classification and used to assess the potential of each agro-ecological zone within Buhera District to produce food. Combining data on annual rainfall with values of absolute and relative seasonality various indices have been constructed to predict the probability and intensity of seasonal fluctuations on availability of food energy. The IACS has been found to be highly correlated to seasonal weight loss amongst adults in rural communities in developing countries (Ferro-Luzzi, *et al.*, 1987).

Zimbabwe has a uni-modal rainfall pattern; the mean rainfall of Buhera District in recent years ranged between 400-800 mm/yr. The five month rainy season generally starts in late October/early November and ends late March/early April. The crude data and maps published using the IACS categorise Zimbabwe as high to moderate risk of seasonality. One of Buhera's main advantages as a survey site were the distinct geographical distribution of the agro-ecological zones III, IV and V, the three least productive types of land classification. Table 3.1 provides a summary description of the three agro-ecological zones including the range of annual rainfall expected in each zone. All three agro-ecological zones have an annual precipitation <1,000mm. Using this classified system Zone III is classified as moderate-severe risk of seasonality and regions IV and V would experience severe seasonality. This crude risk assessment of seasonality suggests that the Buhera population was at high risk of seasonality. The potential for agricultural production declines southwards. The northern third of the district, categorised as Zone III is considered semi-intensive and self-sufficient in aggregate in non-drought years. In contrast the middle and southern section of Buhera are categorised as Zone IV and V and classified as semi-arid, the driest and least productive land see Map 3.2.

The principal staple crops grown in Buhera are maize, sorghum and millet. Although not recommended for the drier regions hybrid drought tolerant maize seed was distributed and used across the whole district. The Ministry of Agricultural crop forecasts and the Department of Social Welfare relief figures for the period (1989-1993) suggest that during the last decade Buhera had been a food deficit area in both drought and non-drought years. The drought relief figures indicate that almost half (47.4%) the population of the district were receiving food aid (MPSLSW/DSW, 1993; FEWS, 1994). It was assumed that the absence of major drought relief programmes such as irrigation schemes and the relatively long distance to large cities meant that the population in Buhera were largely dependent on their own crop production for food. A combination of marginal rainfall, poor soils, declining hectagre, increased population density and the lack of storage facilities result in crop yields generally insufficient to meet household requirements. At least half of the small-holder farmers do not sell grain during a normal rainfall year and a third of rural households are normally grain purchasers; food stocks last 4-6 months hence the majority of households are food insecure by November/December. This situation increases the households reliance on food purchases.

To supplement the endowment entitlements and ensure an adequate level of food security subsistent agricultural households in Buhera require guaranteed income to provide sufficient exchange entitlements to purchase grain. The household's degree of purchasing power is directly correlated with its socio-economic status. The most recent (1995) Poverty Assessment Report (PASS) suggested that Buhera was the poorest district within Manicaland Province with a total of 89% of the households classified as poor (MPSLSW, 1996). PASS estimated that 74% of the households residing in Buhera District were 'very poor' living below the Food Poverty Line (FPL), 15% were classified as 'poor' living below the Total Consumption Poverty Line (TCPL) and 11% were 'non-poor'. These results illustrate the distribution, intensity and severity of poverty within Buhera and hence the general lack of purchasing power. The Communal Areas are generally under-developed lacking basic infra-structure; in particular employment opportunities are scarce. One of the main coping strategies developed by CA agricultural households to overcome the lack of local income generating projects has been mass adult male migration to find alternative off-farm employment in the urban centers or the mines. By diversifying income sources the households exchange entitlement increase. This situation is verified by the 1992 Census results which suggested that Buhera was one of the highest female dominated district with a gender ratio of 85 males to every 100 females (CSO, 1994).

The level of access to primary health-care, potable water and education within Buhera District was variable. The formal health-care system in Buhera District consisted of one district mission hospital, two rural hospitals and 28 rural clinics. The services and opening times varied by the type of facility. To service the remoter areas the MOH Expanded Programme Immunisation (EPI) team regularly travelled around the district. The two main commercial centres Murambinda and Birchenough Bridge were relatively well supplied with the majority of agricultural and household goods and services but the overall distance between Buhera and the capital city Harare meant that transport costs were high. At the time of the study a return bus journey cost Z$45, 11.3% of the minimum monthly salary. In each ward there was 1-2 shops along the bus route and impromptu markets were set up to service the surrounding kraals. In the markets women sold or bartered vegetable crops and income generating wares such as pottery and knitted clothes. The Buhera government post was considered the main council centre, consisting of a registry, police station, post office and AGRITEX. The council offices were split between Buhera and Murambinda townships. Tarmac roads skirted the northern and southern tip of Buhera District but the principal road, serviced by a bus twice per day, throughout the district was gravel.

In summary, the Buhera study population are by definition communal agricultural households, considered and targeted as nutritionally vulnerable. They are geographically located in a food insecure, under-developed area combined with high levels of intense and severe poverty and these factors begin to explain the persistent high levels of chronic malnutrition amongst under five's evidenced by time series analysis of clinic data. Figure 3.1 depicts the seasonal variation in the prevalence of underweight amongst under five's attending the growth monitoring clinics in Buhera District between 1988-1995.

3.3.3 The household survey protocol: The household survey protocol was designed to capture seasonal fluctuations in dietary access, energy requirements and disease exposure. The research study assumed that nutritional security was influenced by a multitude of factors that operated through a complex set of processes in a highly interactive way. The relatively high level of vulnerability experienced by poor rural communal agricultural households is further compounded by seasonality. Fluctuations in food availability and/or access caused by inadequate supply and/or increase in demand for labour, and the increase in exposure to infectious diseases, each represent different origins of nutritional risk. The household survey protocol reflected these assumptions in its design. Three distinct periods within the agricultural year namely, the *pre-harvest, harvest and post-harvest* periods were identified through consultation with colleagues at Ministry of Health (MOH) and Ministry of Agriculture (MOA). Each season reflects the respective positive and negative impacts of seasonal changes in the food and health system on the population's nutritional status.

To aid development of the study protocol and subsequent analysis an agricultural calendar was devised simultaneously depicting the expected prevailing agricultural cycle, climatic, food and health conditions of *pre-harvest*, *harvest* and *post-harvest* periods. The agricultural cycle associated with maize, sorghum and millet, the main cereal cultivated in Buhera District, dictate the availability and access to food, demand for labour and availability of care. This calendar was subsequently used to identify key months when data on the biological parameters, agro-economic and infra-structural variables should be collected. The survey schedule has been superimposed on the agricultural calendar to indicate how the study periods and alternating rounds of questionnaires and repeated anthropometric measures were used to monitor the three respective seasons (Table 3.7).

The first study period was conducted between Oct-94 and Jan-95 the start of the agricultural cycle. It is evident from the calendar that this period represents the *post-harvest* which generally starts in August and ends around December. The *post-harvest* period represents a time of increased nutritional vulnerability induced by a multitude of combined nutritional stresses caused by decreasing food stocks (harvest being 5/6 months previous). This occurs concurrently with increased demand for energy induced by prevailing agricultural activities (land preparation/ploughing/planting); and the concurrent increased exposure to water-borne diseases associated with the rainy season. Crops are being planted and grain stores from the 1993/4 production are run down. It has been estimated that a quarter of rural farming families run out of food stocks, usually in period November-March, with 40% of them running out of food by December (NCS, 1990, Jayne *et al.*, 1990). Health clinic data revealed relatively high incidences of measles, diarrhoea and malaria amongst pre-school population in Buhera during this period. The anthropometric measurements taken in Nov-94 and Nov-95 were assumed to represent nutritional status during the *post-harvest* period.

The second study period Feb-95 to May-95 was designed to capture the *'pre-harvest'* or *'hungry'* period. During this period it was postulated that the nutritional status of the household members would be negative unless they had started harvesting green maize as they would be reliant on food stocks from the 1993/4 harvest which had occurred 10/11 months previous. Energy demands are still moderately high during this period of the agricultural cycle. Activities such as weeding, spraying and second planting if the first crop has failed increase energy expenditure and also decrease the availability of time for child-care. In addition, the continuation of the rainy season increases exposure to water-borne diseases such as malaria, diarrhoea and bilharzia. The anthropometric measurements taken in Mar-95 were assumed to represent nutritional status in the *pre-harvest* or *hungry* period.

The third study period Jun-95 to Sep-95 was designed to represent the '*harvest' and 'winter'* period. In Zimbabwe, the maize and sorghum harvests occurs between April-June each year. With regard to maize, there follows a few months of shelling and then the maize is allowed to dry thoroughly before being transferred to granaries for storage. This period is considered relatively less stressful within the agricultural cycle, food stocks are still reasonably high in a normal year, energy output in terms of agricultural activities is low, and incidence of water-borne diseases decrease as rainfall is minimal. It was postulated that the population's nutritional status would be optimal at this time. However, the quality of the diet may be poor since in normal years many rural households experience shortages of green vegetables and milk during the winter months (May-October) (Tagwireyi and Greiner, 1994). At this time the adequacy of dietary intake is dependent on harvest proficiency, access to gardens and animals to ensure dietary diversity. In addition, the relatively lower temperatures observed during the winter months have been reported to have a marked impact on incidence of respiratory diseases. The anthropometric measurements taken in Jul-95 were assumed to represent nutritional status in the *winter* period.

3.3.4 Schedule of Household Level Survey Field Activities: The study time-table and the household survey field schedule by month are presented in Table 3.8. Field activities started in Jul-94 with the recruitment of the survey team and implementation of the sampling plan. Ten enumerators, all residents of Buhera with secondary school education, were recruited to assist with the administration of the questionnaires. The enumerators were supervised by two team supervisors, Mr Dhuka an experienced research supervisor and a MSc Agriculture Economics student Mr Kudlande. In addition four state registered nurses were seconded from the MOH to work in pairs alongside the author to collect anthropometric measures. The administration of household survey questionnaires began in Oct-94 and was completed at the end of Nov-95. Each of the 354 households were enumerated a total of 10 times. During each survey round 1-3 different questionnaires were administered to a pre-specified household respondent who varied depending on the type of information sought. A set of eight different questionnaires were developed, namely demographic, income and assets, crop production, food flows, off-farm income, 24 hr food recall, food frequency and health status.

3.3.5 The sampling strategy: To ensure a representative sample, a stratified multi-stage cluster sample strategy was used to select the survey population. The three levels of stratification were designed to capture the variation in access to food, formal health-care and potable water. Each of these factors were assumed to operate at different geographical scales. The existing hierarchical administration system of district, ward, vidco and village were used as the primary sampling units (PSU) for each level of stratification.

The government administration system divides districts into wards or Ward Committees (WADCO), at the time of sampling there were 30 wards in Buhera. Each ward consists of 6-7 Village Development Committees (VIDCO) and within each VIDCO there are 5-6 smaller villages or kraals. The approximate population size of each hierarchy of the administration system within Buhera are summarised in Table 3.2.

The sampling strategy was implemented over a four month period. During this time the necessary information required to implement the sampling plan was collected and verified by the research team. The data sets used included maps of agro-ecological zones, health centres, roads and topography and the administrative boundaries. These basic map layers were digitised and collated using a geographic information system (GIS). Dr J. Wright, the team geographer who was responsible for all GIS calculations.

The first level of stratification carried out within Buhera District was at ward level. Each ward was selected on the basis of agro-ecological zone. Intra-ward variation in agro-ecological conditions was not easily verified. The final classification of each ward by agro-ecological zone was carried out by overlaying the agro-ecological zone and ward maps using the GIS. The predominant agro-ecological zone i.e. the one which covered the greatest area within the ward was assigned. Wards were then randomly selected from each agro-ecological zone in proportion to the total area (km^2) of Buhera District within that zone. Ten wards or a third of total in the district were chosen.

The second stratification was conducted within the Wards at VIDCO level. These were selected on the basis of access to health-care. Four (4) separate maps were created which calculated distance to the four different types of formal health-care available in Buhera (hospitals, rural hospitals, clinics and outreach centres) for each VIDCO. The distance calculation took into account the effects of roads (different types: tarmac, primary, secondary and tertiary non-tarmac) and obstacles such as hills and rivers, thereby providing a more realistic assessment of physical access. The four separate maps were then combined into one composite health-care access index. This involved weighting each type of health-care facility by the services offered and opening times as summarised in Table 3.3. The Ministry of Health (MOH) staff in Buhera were shown a series of maps to verify its accuracy in reflecting health-care access within the district.

The third level of stratification was carried out at village level. Villages were selected on the basis of household access to potable water. This was determined using a rapid appraisal of local water supplies. Village chiefs listed all water sources and the number of months of year each water source was available. The possible types of water sources, the standardised definitions and the weighting system used are listed in Table 3.4. The potable water index was developed in collaboration with district level MOH staff responsible for hygiene and sanitation. The composite potable water index was determined by multiplying the number of each (specified water source) by the number of months available by a weighting factor which reflected the potability of the water source. This was repeated for all water sources and summed. The weights for each type of water represent subjective opinions about the propensity of that water source to contamination.

The following assumptions were made when assessing access to water: i) wells were replenished seasonally in December, ii) each village had an equal population and that each well yielded the same quantity of water; iii) villagers do use natural springs as water sources (natural wells are used, but their locations are jealously guarded secrets and therefore a sensitive issue); iv) all villagers have equal access to the water sources; v) the definitions of each water source have been applied consistently to each village. 'Good' and 'bad' access to water were defined using the median value of the water access index as a cut-off point. Three kraals were selected from within each VIDCO in proportion to the observed water access.

Finally households were chosen from selected kraals at random. Households lists for each kraal were created by the enumerators. Household selection was carried out at village level meetings where the objectives of the study were explained to the population. Names of households heads were placed in a hat and selected at random. This selection process endeavoured to ensure that the whole village population were aware of the study aims and the impartial selection of households.

3.3.6 Determining the adequacy of sample size: The final sample size of 354 households was selected as a compromise between balancing statistical 'representativeness' with resource and logistical constraints. Generally sample sizes are determined by three factors: i) the prevalence and variation of malnutrition within the population, ii) desired precision and level of confidence; the survey estimate should actually reflect the true prevalence of malnutrition within the community and iii) the complexity of the sample design (Mascie-Taylor, 1994; Cole, 1998).

A reasonable 'guestimate' of the expected prevalence is usually a prerequisite for estimating sample size; these were obtained from MOH clinic growth monitoring data and previous anthropometric studies conducted within the last five years in the communal sector. The seasonal prevalence of underweight[1] amongst pre-school children in Buhera District disaggregated by three age classes by month for the previous 7 years were analysed and combined with prevalence rates of pre-school child stunting, wasting and maternal chronic energy deficiency (CED) estimated by the ZDHS (1994) and a nutrition study conducted amongst communal agricultural household in Chivu District (Pastore, 1992; CSO, 1995). These nutrition studies

[1] Underweight is defined as below 3rd centile from the median of the NCHS/WHO/CDC reference

suggested that pre-school child stunting, underweight and wasting was approximately 25%, 15%, and 10%, respectively. Since, the pre-school population is generally considered more nutritionally vulnerable it was assumed that the pre-school malnutrition rates would represent the maximum expected prevalence of malnutrition amongst primary school and adolescents. Published data on adult nutritional status is scarce. The 1994 ZDHS suggested that 4.2% of non-pregnant non-lactating women living Manicaland had a BMI (Body Mass Index) <18.5 which is indicative of CED (CSO, 1995). In comparison results generated from a household survey conducted in a communal area in Chivu District a comparable environment to Buhera reported relatively higher levels of CED, 14.2% amongst adult males and 11.8% amongst females (Pastore, 1992). These malnutrition rates were used to estimate sample sizes required to capture the true proportion of child and adult malnutrition. The sample size was initially determined using a conventional cross-sectional simple random sample design with no design effect, a 95% confidence interval and 5% sampling error assuming that the ecological conditions would be within normal parameters. The formula below was used to determine sample size:

$$n = \frac{(Z)^2 p(1-p)}{r^2}$$

Where:
n = size of sample
Z = confidence interval
p = probability (estimate of prevalence of malnutrition)
r^2 = sampling error

Applying this formula the estimated sample size required to capture 25% stunting, 15% underweight and 10% wasting within 5% of these values and with 95% confidence was 324, 196, 137 children, respectively. These sample size estimates were subsequently doubled to accommodate the anticipated seasonal variation in participation rates of 70-80% and a conservative estimate of 10% panel attrition caused by longitudinal nature of the study. Increasing, the sample size by 50% resulted in at least 648 children, 392 adult males and 274 adult females had to be measured to capture the true variation of the malnutrition within the Buhera

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population weight for age.

population. These sample sizes were fulfilled for all age groups except adult males; just over half the required sample were measured due to male migration. The under representation of men in this study is discussed during the analyses.

3.3.7 Estimate of design effect of the sampling plan: The complex sampling strategy used in the IMFSZ study which used both cluster and optimisation in multistage selection reflects the emergence of sophisticated techniques used to ensure representative samples within logistical reach. In the Buhera study the sampling plan was used to ensure that the distribution of the population living within each agro-ecological zone, with good and bad access to health-care and water was representative. The main limitation of complex sampling strategies is the design effect caused by unequal probabilities. The design effect reflects the estimated variance of the survey data relative to that of a simple random sample. Usually stratification reduces the design effect narrowing the confidence limits, whereas cluster sampling tends to increase the variance, widening the confidence limits.

The 1994 Population Census provided an estimate of the number of wards, vidcos, villages, households and population within each strata; this was used to estimate selection probabilities. The absolute sample size is more important than sample size relative to the whole population although it is evident that by comparing the number of households selected that approximately 1% Buhera District was surveyed. The variation of the number of each wards, VIDCO's and villages being selected did not vary sufficiently within each strata to affect the probability of being selected.

The design effect of the Buhera sampling strategy was estimated using the C-SAMPLE programe within EPI6 that is in the public domain and freely accessed via the INTERNET http://www.cdc.gov/epiinfo/. The variance calculations in CSAMPLE uses the Taylor Linearized Deviation approach. This approach approximates the variance by using the following simple formula:

$$\text{Design effect} = (\text{SE study design}/\text{SE simple design})^2$$

Where: SE = sampling error

The estimates of the sampling errors which were subsequently squared to approximate the resultant design effect at the Ward level for anthropometric variables WA, HA, WH and BMI generated from measures collected in Mar-95 are summarised in Table 3.6. The design effect for a multi-stage cluster sample usually exceeds one whereas for a random sample it will be near or slightly less than one. The design effect is considered limited if the variance is less than double the simple random sample (Cole, 1998). A design effect of two means that twice as many individuals must be studied to obtain the same precision. The calculation in CSAMPLE suggests that the design effect for the Buhera sampling strategy was limited, slightly exceeding 2 in only three cases, WA male 12-59 mths. (2.30), HA for females aged <12 mths. (2.18) and WH females aged 12-59 mths. (2.27). These results suggest that it is plausible to analyse the anthropometric indices as though the sample population had been selected as a simple random survey. It was not necessary to factor in the study design.

3.3.8 Questionnaire development: A set of eight separate questionnaires were developed after reviewing previously devised research instruments used by UZ, Edinburgh and INN researchers. Prior to the administration of each questionnaire the forms were extensively examined for conceptual and technical limitations by colleagues with food and nutrition security field experience. The questionnaires were translated from English into Shona and then pre-tested by enumerators, modified and subsequently administered to appropriate key respondents within the household. A three to four day training programme for the enumerators was conducted a week prior to each survey round to ensure a common understanding of its objective and to establish a standardised procedure for its administration and an agreed common translation. The administrative procedures and translations were subsequently recorded in a manual for future reference. The majority of questions were designed using a closed pre-coded format to aid in the accuracy and efficiency of data collection and entry. A copy of each questionnaire can be found in Appendix 1.

Demographic questionnaire was used to ascertain the household demographic profile and assess the household environment. Demographic data has a multifacted role in the study of nutrition, partially as a denominator, the size, distribution and composition of the population affect resource requirements, determine the type and amount of food and health-care required. The gender and age structure of the population is a pre-requisite for determining the demand side of the nutrition security equation. Demographic variables are also used as predictors or covariates, age and gender directly influencing nutrition exposure (Mcintyre and Anderson, 1998). Demographic attributes at the individual and household level are often used as targeting mechanisms.

The individual and household level demographic variables used within this thesis are listed in Table 3.10-3.11. The demographic questionnaire was administered twice to capture population dynamics including, newborns, deaths and seasonal change in residency status (in and outward migrants affect household resource requirements). Chapter 4 outlines the procedure used by the author to define, verify and classify residency and ascertain resident status.

The *income and assets questionnaire* obtained the number of household, agricultural and livestock assets owned. This data was used to provide an indication of wealth, long term investment and liquid assets which could be used as buffers.

Off-farm income questionnaire was used to capture the seasonal variation of income sources by activity. The primary objective was to elicit the amount of cash and in-kind income earned during the previous 4-month period. To reflect the diversity of household income three broad income categories were included namely, remittances (income obtained from household members living away); income generating activities undertaken by residents excluding crop production; lastly, passive forms of income such as pension and one-off payments such as bridal wealth (Lobola).

The *food flows questionnaire* determined the seasonal dynamics of household food stocks (main staples). The amount and change in the level of each staple were monitored by source (purchases, sales, borrowings, loans, and other uses/receipts). In this thesis this data was primarily used to estimate household income and expenditure to derive a wealth index.

24 hr recall questionnaire and food frequency questionnaire (FFQ) two complementary indirect methods were used to assess dietary consumption patterns. These questionnaires were repeated three times during the year (March, July and November) to capture seasonal changes in the quantity and quality of the household dietary consumption pattern. A semi-quantitative *24 hour recall questionnaire* was used to determine the number of meals, quantity of ingredients consumed per day by source (own production, food aid, wild). The trained enumerators asked the target respondent, generally the oldest female responsible for meal preparation, to recall all meals, dishes, drinks and the respective ingredients prepared, cooked and consumed the previous day. The respondent estimated the quantity of food prepared using one of 12 different commonly used household measures (measuring cups, containers and spoons) or when appropriate the size of the actual food package was noted. Household measures were subsequently converted to grams. A mean weight derived from the three separate conversions was carried out by Nutrition under-graduates at UZ. The mean weights were recorded in a separate table within the database.

The *food frequency questionnaire (FFQ)* was used to capture seasonal day to day variability of the diet, estimate household expenditure and quantity of foods stored for future consumption. The FFQ design was originally based on the list of foods complied by Benhura and Chitsiku's (1990, 1991, 1992) for the Mutambara District Food Consumption Study. This initial food list was pre-tested in Buhera in Oct-1994 and subsequently modified to incorporate wild foods particular to Buhera District. The final FFQ used a comprehensive list of foods consisting of 158 different commodities. Each food was classified into one of twelve different food groups, namely cereals, roots/tubers, legumes, leafy vegetables, other vegetables, fruits, meat/fish, insects, dairy products, fats & oils, beverages, sweets. The respondent estimated the frequency category (<1 per day, once per day, 3-6 times per week, once or twice per week or once or less than once per month) the commodity was consumed. Where appropriate the mean quantity of each commodity and its source (own production, purchased, gift, wild food, drought relief, borrowed, food for work) was recorded. This data was used to develop a series of crude proxies/indicators of dietary diversity including, the total number of different foods (FVS) and total number of food groups (DDS) consumed in each four monthly period by each household by frequency category.

The FFQ was also used to estimate monthly household expenditure for 36 food items and 16 household items. The cash and in-kind items used to procure each article were converted to cash and summed to give total monthly household expenditure. The FFQ also collected information pertaining to household food stocks. The respondent estimated the amount in kilograms (kg) of 16 pre-determined food commodities that were stored for present and future consumption. See Appendix 1 for a sample FFQ; it should be noted that unlike other questionnaires the FFQ was not modified throughout the study.

In May, the *crop questionnaire* was administered to assess the households arable and horticultural production. Information related to agricultural inputs (labour, traction, seed and fertiliser) were noted so that factors contributing to yield levels could be assessed. In addition, data related to vegetables grown in gardens was also noted.

Health status questionnaire was considered an integral mediating factor in the determination of nutritional status due to any disease or illness having a direct negative impact on nutritional status. The *health (morbidity) status questionnaire* was administered to i) establish the type, incidence and duration of illnesses; ii) assess the indirect impact of carer's or income earner's illness on the dependant's nutritional status; iii) evaluate household access and utilisation of formal preventative and curative medicine and use of the traditional and religious sector; iv) evaluate the links between commonly associated health factors (immunisation coverage, utilisation of growth monitoring, reasons for non-utilisation of growth monitoring, feeding practices) with nutritional status of under five's; v) assess the incidence of mortality during the study by age and gender.

Ill-health was self diagnosed or evaluated by the adult carer. Generally the target respondent was the eldest adult female, who recalled which household members had been ill within the previous two weeks. For each illness the main symptoms and 'number of days sick, 'number of days lost at work/school' and/or 'carrying out domestic chores' were reported. The enumerators were trained to elicit health information sensitively; it was particularly stressed that only the symptoms should be recorded, personal medical diagnoses were discouraged. The symptoms were initially recorded using local descriptive terms rather than using standard medical definitions of infection. All illnesses were broadly categorised. No attempt was made to differentiate the severity of diarrhoea for example the level of dehydration or distinguish between upper and lower respiratory tract infections. After data entry all symptoms were subsequently translated into English and grouped into 10 broad categorises.

3.3.9 Anthropometric measurement protocol: The anthropometric team consisted of two technical nutritionists and four supervised nurses. A two day training session was held one week prior to each survey round during which the accuracy and precision of the measuring team was assessed in accordance with standard procedures (WHO, 1983). The results of the anthropometric standardisation are summarised in the quality control section 3.4.3.

Anthropometric measurements were performed in pre-selected centrally located measuring centers, where 2-3 villages were convened. A total of twenty sites were used, each conforming to a pre-established minimum set of conditions including: ease of accessibility - within 3-5 km walking distance from each selected villages. A light, weatherproof spacious (8-10 person) room with a flat floor that was also a culturally acceptable meeting place. The VIDCO chairman assisted in the identification of appropriate sites within their jurisdiction. Permission to use the centre was sought from the appropriate authorities prior to each survey round.

To ensure maximum participation rates during the longitudinal study the anthropometric team split into two groups. One team was stationed at the central measuring site while the second was mobile visiting each primary and secondary school within the catchment area. Adults and the very young household members were measured at central sites. The school-age population were measured at their respective primary and secondary education institutions. Each round of anthropometric measures took 20 days i.e. one month to complete. A follow up of absentees from the measurement session was made on a house to house basis on the same day when time permitted.

Weight measurements: The participants weight was measured on Sohenle battery operated weighing scales with digital read-out (130 ± 0.1 kg). The scales were positioned on a flat surface, a spirit level was used to check that the scale were balanced after each time it was moved. A pair of feet were drawn on the top surface of the scales to ensure that the participants stood in the middle of the scale. Adults were measured wearing minimum clothing and barefoot. Infants and very young children were weighed in their adult carer's arms, the weight of the adult carer was taken separately and subsequently subtracted at the data entry stage. All clothing worn by the participants was pre-coded on the anthropometric form. The weights of the 10 pieces of clothing were averaged for each age range. The mean weights for each piece of clothing worn by the participant were summed and then subtracted from the original body weight during data processing. All weight measurements were recorded in kilograms to one decimal place.

Scale calibration: Each scale was calibrated daily using calibration weights 5-30 kg. If the scale was moved from site to site during the day the calibration was repeated. The deviation in weight of each respective scale was constant i.e. it did not fluctuate daily. The daily calibrations should have been extended to 100 kg but due to resource constraints, the appropriate calibration weights were not obtained. To overcome the limited range of calibration conducted during the field study, the scales were calibrated for the whole measurement range 5-130 kg at the Zimbabwean government weights and measures centre. Each scale was calibrated at 5kg interval for the range of weights between 5-130 kg. This calibration process required two people to place the appropriate number of weights on top of each other in the centre of the scale. To check the scale precision the calibration was repeated three times for each value. The scale calibration results are presented in Appendix 1-Table A1. Each scale was allocated a number, this number was recorded on the anthropometric form against the individual's weight and entered into the database. The scale deviations were subtracted from the individuals' body weight during data processing. The implications of the scale deviations are discussed in the section on data quality control 3.4.3.

Stature: Stature was measured using the standard technique described by Weiner and Lourie (1969) on all the individuals aged >2 years or with length longer than 85 cm using a Raven minimetre. The portable Raven measuring tape was temporarily fixed to a locally made wooden height board designed by Mucavele & Makombe, 1994 see Photo 3. The wooden boards were designed at the request of the respective measuring centres, to avoid drilling holes into the walls to hang the standiometer. Each participant compiled with the request to remove all head wear, braids and foot-ware. The participant stood in the centre of the wooden board under the arm of the Raven standiometer facing the measurer. The participants feet were together, arms by their side and their heels, and torso touched the back of the wooden board. The subject was gently stretched upwards by being held under the mastoids and asked to inhale and exhale while the head was positioned with the external auditory meatus and the outer canthus of the eye in the same horizontal place (Frankfurt plane). The measurement was taken after the arm of the Raven stadiometer was brought gently down onto the subject's head. Height measurements were recorded in centimetres to one decimal place, these measures were subsequently converted to metres during data processing. The precision of the Raven stadiometer was checked each time it was moved and after measuring ten participants by ensuring that the dial read zero when it touched the base of the wooden board.

Recumbent length (crown to heel length) measurements were taken on infants aged <2 years or less than 85 cm in length by recommended techniques (Jelliffe and Jelliffe, 1989; FAO, 1990; WHO, 1995). This measure was taken using the procedure described by Weiner and Lourie (1969) using a Raven rollametre (0 - 100 cm in 0.1 cm graduations). The semi-rigid measuring mat was placed on a flat surface (usually the floor covered with a mat or 'Zambia'). The infant was laid on measuring mat, with their head positioned against the hard plastic headboard, the eyes of the child looking vertical. The legs were straightened and the knees were kept together and extended using gentle pressure applied by the assistant measurer. The feet were placed upright at right angles. The plastic upright sliding foot-piece of the rollametre was moved to obtain firm contact with the heels and the length was measured in centimetres to one decimal place. When possible the mother or adult carer were involved standing within eye contact to provide reassurance to the infant. In cases where the technique used to take the infant's stature changed during the study 0.5 cm was subtracted from the length measure before comparing it to subsequent standing height measures. This was carried out at the data processing stage. Recumbent length or length throughout this thesis refer to measurements of linear growth made with child lying down while stature refers to measurements made with the individual erect or standing. Height may refer to either recumbent length or stature measurements.

Mid-upper arm circumference (MUAC) measurements: MUAC measurements were obtained from all resident household members aged over six months using the technique described by Jelliffe and Jelliffe (1989). As recommended, the left arm was measured in the majority of cases, except when the individual specified that they were left-handed or their left arm was broken. The mid-point of the arm was located between the acromium process and the elbow while the arm was flexed at 90° across the chest. A fine tip red pen was used to mark the site of the mid-point. The MUAC measurement was taken while the subject's arm was hanging loosely by the subjects side. A flexible non-stretchable metal Holtain tape was placed on the mid-point and held in position not too tightly or too loosely. The easily readable Holtain was graduated in 0.1 cm. All MUAC measurements were recorded on the anthropometric form in centimetres to one decimal place.

The Anthropometric Form: The anthropometric forms were modified during each survey round. In the trial round (Nov-1994) the form was blank and the personal details were recorded laboriously by hand. After the data from the demographic questionnaire had been entered, personal characteristics including, name, DOB, previous weight, height, MUAC were pre-printed on the anthropometric forms. This procedure was efficient and enhanced data accuracy, allowing the nurses to verify personal details, resident status and identity. Additional comments such as reasons for non-attendance, reason for weight gain or loss since previous round were recorded on an ad hoc basis. All women of child bearing age were asked if they were pregnant or lactating. The number of months pregnant or lactating were recorded and entered in the database. Respondents measured in July and November 1995 was asked if they had been healthy or sick during the previous two weeks. This additional source of health information was collected after preliminary analysis of the responses received from the health status questionnaire suggested under-reporting amongst male adults.

Age Data: Age data was collected where possible by official documents (birth certificates, child health cards, national ID cards, voters cards). Where official age information was not available the respondent, adult carer or teacher was asked to give date of birth or age estimation. If the adult carer attended they were interviewed using a local calendar produced by the enumerators to determine age of their children. The origin of the DOB and age information was recorded on the anthropometric form so that further analysis could be carried out to establish the influence of the source of age information (i.e. official versus unofficial) on the nutritional status of children.

3.4 Analytical Framework

3.4.1 Data entry and data management: The Buhera study generated a large volume of data of a complex nature. A relational database was designed using a series of tables; these tables closely mirrored the content of the questionnaires. A data entry form replicating the design of questionnaire was used to aid the data entry clerks. Validation criterion were set up within each field to reduce the number of incorrect entries. A separate table was created for each specific question of each round of questionnaires. As the name 'relational' implies, the separate tables can be related to each other through the creation and use of unique identification codes. Each household and each individual within the household had an unique identification code. The main advantage of a relational database is its efficiency; each table includes only individuals responding to a particular question, unlike flat files which include all respondents irrespective of whether they participate. The decentralised nature of the relational database was particularly useful for the Buhera study since many questions were targeted to specific groups within the household (pre-school children, pregnant and lactating women, non resident remitters). However, the use of a decentralised system also has its limitations, increasing the risk of missing or misidentified individuals and duplication. A variety of data cleaning methods were employed to check for error.

3.4.2 Data cleaning: To reduce the number of data entry errors, outliers and mismatched responses were cleaned by using a number of techniques including, visually checking data entry print-outs against the original questionnaires. The anthropometric data was also double-entered (two people entered the data independently) and checked for consistency and correctness. The large numbers of entries related to the 24 hour and FFQ, restricted cleaning to the count of the number of rows in a table. The longitudinal nature of the study permitted a series of intra subject comparisons and logical checks to check the reliability of a response over-time. The reliability of the data was checked by comparing the estimates to external sources such as the ZDHS (1994) and the most recent Population Census (1992). After checking the data and editing the corrections, various combinations of individual, household and community level files were constructed and imported to the Statistical Package for Social Sciences (SPSS version 9.0 for Windows).

3.4.3 Data quality:

Results of the scale calibration: Three methods were used to calibrate the scales have been discussed in section 3.3.8. In Appendix 1, Figure A1 and A2 and Table A1 summarise the mean scale deviation observed during study by scale number. It is evident from the results that the scales deviated in a positive virtually linearly way. The scale deviations varied by ±0.1 suggesting that the scale deviations were consistent over-time allowing mean deviation to be calculated and subsequently subtracted from the subjects body weight after data entry. However, the consistency between scales and within the scale graduations varied at different values. Figure A1 graphically illustrates the scale deviations observed for the same 10 subjects. The lack of reliability of the scales had a number of serious implications for the results of the study.

Weight based anthropometric indicators, absolute weight and relative weight are key sources of information used to assess change in nutritional status. To eliminate the impact of the scale deviations on all subjects scale adjustment factors were subtracted after data entry. Evaluating the results of the scale deviations using Zerfas (1986) categories it is evident that the reliability and accuracy of the three scales used to measure body weights ≥70 kg can be classed as good, poor and causing blunders for scale 3, 2, 1, respectively. An evaluation of impact of the scale deviations on the reliability and accuracy of reported child and adult body weights was made using Barigai (1986) theoretical model. All children aged <10 years and the majority (79.1%) of children aged between 10-17.99 years weighed <45 kg the impact of minimum maximum scale deviation ±0.1-0.4 kg on the reported prevalence of malnutrition was estimated. Appendix 1-Table A2 provides the percentage change in the estimates of malnutrition due to an additional 0.1 kg or 0.4 kg mean scale deviation added to the child's body weight. It is evident that a systematic scale bias of 0.1 kg would cause an under-estimation of the prevalence of underweight by 8% if the population was aged 2 months or 1.1% if they were aged 18 years. Whereas a bias of additional 0.4 kg would cause an under-estimation of nearly 30% amongst infants aged 2 months and 2.4% amongst adolescents aged 18 years. These values illustrate the importance of subtracting the respective scale deviations[2].

Results of the anthropometric standardisation test: The anthropometric team consisted of two technical nutritionists and four nurses. A two day training session was held one week prior to each survey round to assess the accuracy and precision of the measuring team in accordance with standard procedures explained in WHO (1983) and Zerfas (1989). The repeated standardisation tests provided an opportunity to re-fresh procedures and to familiarise the nurses with any modifications to the anthropometric form.

The precision of the observer is estimated by comparing the results of two independent measures. The precision of the observer is defined as the ability to repeat the measurement of the same subject with minimal variation. The accuracy of the observer is defined as the ability to obtain a measurement which duplicates as closely as possible that of the supervisor or the mean of the group of observers. It is commonly assumed that the supervisor's measures are the most reliable having had more experience in measuring the human body. This pragmatic practice of accepting the supervisor's measures as a *'gold standard'* was inappropriate since there were five observers it was considered more important that the inter-observer error was measured.

The methodology used for the anthropometric standardisation test in the Buhera study was adapted from Zerfas (1986) and WHO (1983). Ten subjects of varying age (young infants to elderly) and nutritional status (thin, normal, overweight and obese) were measured twice by each observer. The first and second measurement were independently taken after an appropriate interval and recorded on separate forms. The

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Note:The manufacturers and suppliers of the Solhenlne scale were notified of the deviations observed and since conducting this study this make of scale is no longer stocked.

results of the standardisation were computed and any discrepancies in procedure used were discussed and corrected.

To be able to accurately interpret growth and physique measurement, anthropometric estimates of measurement error, are needed. No universal standard methodology or terminology exists Mueller and Martorell (1988) and Frisancho (1990) have attempted to clarify this issue. They both suggest that the use of two error estimates, the technical error of measurement (TEM) and the coefficient of reliability [R] give most of the information needed to determine whether a series of anthropometric measurements are accurate. The intra-observer TEM in the Buhera study was calculated using the two independent weight, height and MUAC measures taken during each anthropometric standardisation using the following formula given in Ulijaszek and Lourie, 1994.

$$TEM = \sqrt{\frac{\sum D^2}{2N}} \qquad [1.1]$$

Where:
D = difference between measurements
N = number of individuals measured.

The coefficient of reliability, R, was calculated using the following equation (Ulijaszek and Lourie, 1994).

$$R = 1 - \{(TEM)^2/(SD)^2\} \qquad [1.2]$$

Where:
SD= inter-subject variance

The intra-observer TEM and R are summarised in Appendix 1- Tables A4-A15. All the repeated weight, height and MUAC measurements were close to the reference TEM as recommended by Ulijaszek and Lourie 1998. The intra-observer TEM in the Buhera study varied between body measures. As expected, weight was the most precise measure the TEM ranged between 0.02-0.09. Whereas MUAC was the least precise ranging between 0.09-0.6. No bias was observed. It is recognised that the (TEM) varies with the age of the subject however, the relatively small sample of people measured during each anthropometric standardisation did not permit this analysis. The co-efficient of reliability for all measures was high, estimated to be between 0.97-0.99 suggesting that the repeated measures were 97-99% error-free.

The inter-observer TEM was slightly more complex since there was five observers:

$$\sqrt{\text{TEM} = ((\Sigma_1{}^N((\Sigma_1{}^K M^2)-((\Sigma_1{}^K M^2/K)))/N(K-1)),} \qquad [1.3]$$

Where:
M = the measurement.
N = number of subjects,
K= number of observers (assuming one determination per observer) for the variable taken on each subject,

In order to compare TEM collected on different measures, Norton and Olds (1996) have recommended the conversion of the absolute TEM to relative TEM (%TEM), that is the measure of coefficient of variance (CV). This formula was used to compare the respective intra-observer and inter observer TEM.

$$\%\ \text{TEM} = (\text{TEM/mean}) \times 100 \qquad [1.4]$$

The results and calculation of inter-observer TEM and R by measure and anthropometric standard test are presented in Appendix 1. The inter- observer TEM were compared to and within the parameters as outlined by Ulijaszek and Lourie 1998. The inter-observer TEM's are similar to those measured for intra-observer TEM. It was expected that intra-observer error would be smaller than inter-observer error since the inclusion of many observers increases the probability of error due to differences in measurement technique, this however was not the case. The high coefficient of reliability observed within and between observers suggested that the observers techniques were both precise and accurate.

3.4.4 Data processing: After completion of data entry, the information was processed to derive a number of indices. These indices were subsequently used to represent the dependent and independent individual, household and community level variables. Each indice was constructed to represent a factor associated with nutritional status. The study resources did not permit detailed individual level information on all factors. In these cases household level variables were used as a proxy.

3.4.5 Data - Dependent variables

Derivation of anthropometric parameters: To assess the level of chronic malnutrition, anthropometric measurements taken from all members of the sampled households were used as proxies for nutritional status. Three body measurements: height, weight and MUAC were taken at three key times during the agricultural year. The mixed longitudinal cross-sectional anthropometric surveys conducted between Nov-94 and Nov-95 at 4-monthly intervals were analysed cross-sectionally. The largest sample (Mar-95) was used to establish baseline nutritional status.

The WHO (1983, 1986, 1995) recommendations for the presentation and use of child weight and height data for assessing nutritional status were used to derive anthropometric indices and determine nutritional status. Growth performance was assessed by comparing the observed attained weight and height measures to the median height-for-age (HA), weight-for-height (WH) and weight-for-age (WA) values of the National Centre of Health Statistics (NCHS) international sex specific growth reference standards as recommended by WHO (WHO, 1985, 1995). Each child's anthropometric indices were computed by importing the children's weight, height, gender and age into ANTHRO an anthropometric software package developed by the Centre for Disease Control (CDC, 1988). This software is specifically designed to compare and compute the Z-score deviation between the observed weight and height measures from the NCHS growth reference median.

Anthropometric indice cut-off points and trigger levels used to diagnose malnutrition: The observed deviations were expressed as Z-scores and subsequently used to diagnose the presence, type (stunting, underweight, thinness, wasting) and severity (mild, moderate or severe) of malnutrition using recommended pre-specified cut-off points and trigger levels (WHO, 1995). If a child is adequately nourished the expected Z-score value is close to 0. A Z-score <-3.00 was used to indicate *'severe'* malnutrition, between -3.00 and -2.01 *'moderate'* malnutrition, -2.00 to -1.01 *'mild'* malnutrition, and ≥-1.00 were considered within normal parameters.

Prevalence rates of malnutrition were estimated by calculating the proportion of the sample below -3, -2 -1 Z-scores expressed as a percentage of the total sample measured. In the NCHS reference population against which the Buhera data were compared there was a 'normal' (or 'expected') proportion of children even if they are *'truly'* healthy with no growth impairment that will fall -1 , -2 and -3 Z-scores below the median, these expected proportions are about 15.9% (or 1 in six), 2.3% (or 1 in 40) and 0.1% (or 1 in 200), respectively. To obtain a *'true'* estimate of the prevalence of malnutrition in Buhera in excess of the expected prevalence, these expected proportions are subtracted from the observed prevalence (WHO, 1983).

Trigger levels i.e. the proportion or percent of sample below a cut-off point that determines or 'triggers' (initiates) the need for and type of intervention and for establishing priorities for the allocation of resources were used to evaluate and diagnose the severity of the nutrition situation in Buhera. The prevalence rates of malnutrition observed during the study were assessed in relation to the trigger levels recommended by WHO (1986, 1995) and more recently Gorstein *et al* (1994).

Diagnosis of adult nutritional status: Adult anthropometric status was principally diagnosed using recently recommended BMI cut-off points (Shetty and James, 1994; WHO 1995). The general cut-off point used to diagnose CED is BMI: <18.5 kg/m^2 and obesity BMI ≥30. Various grades within the spectrum of adult nutrition include: severe thinness (BMI: <16.0 kg/m^2), moderate thinness (BMI: 16.0-16.9 kg/m^2); mild thinness (BMI: 17.0-18.4 kg/m^2), adequate weight for height (BMI: 18.5-24.99 kg/m^2), overweight grade I (BMI: 25.00-29.99 kg/m^2), overweight grade II (BMI: 30.00-39.99 kg/m^2), overweight grade III (BMI: > 40.00 kg/m^2), (WHO 1995).

To evaluate the prevalence rates of CED (BMI: <18.5 kg/m^2) and obesity (BMI: (BMI: ≥30 kg/m^2) and define the public health problem, WHO (1995) suggest the following classification system: 3-5% as 'normal' situation, 5-9% a 'low' situation, 10-19% medium or 'poor' situation, 20-39% as high or 'serious' situation and ≥ 40% as very high prevalence 'critical' situation.

Derivation of age groups: The child and adult anthropometric measures and indicators are analysed in two ways using the three distinct periods of childhood: infancy and pre-school years (0-4.99 years), middle childhood (5-9.99 years) and pubescence and adolescence (10-17.99 years) and the three discrete periods of adulthood: young adults (18-21.99 years), middle-age (22-59.99 years) and old-age (≥60 years). To reflect the heterogeneous nature and pattern of malnutrition within each discrete period of childhood and adulthood the age groups are disaggregated further and analysed by yearly age classes within the child population and by quintals and decades for the adult population. This disaggregation is used to illustrate the variance in growth during infancy, the pre-school years, puberty and adolescence and the subsequent changes in body composition that occur during middle-age and old-age. Gender differences in the pattern and performance of growth within the child population and the differences in the body composition of male and female adults are emphasised. By combining the gender and age analyses the demographic profile of most nutritionally at-risk and vulnerable periods during the life-span within the study population are identified.

Parameters to assess seasonal change in nutritional status: The physiological impact of seasonality was estimated by computing the differences in the anthropometric measure and index over each 4-monthly period. These variations were used as proxies to represent change in energy stores (body fat) and fat-free mass (body protein). Although, relatively crude these measures are considered valid since in principle a decrease in body weight is one of the earliest biological expressions of a negative energy balance. Generally, intra-individual daily variation in body weight is within the range ±0.5 kg but the lack of food or illness can precipitate an individual's nutritional status to change very quickly. It is argued that (excepting natural or man-made calamities) the nutritional status of a whole population changes very slowly and any significant differences observed from one observation period to another provides a reliable indication of the change in nutritional risk.

Three parameters were used to provide an estimate of the change in adult nutritional status between each 4-monthly observation period: i) absolute deviations in weight, MUAC and BMI expressed in kilograms and centimetres; ii) relative change in weight, MUAC and BMI expressed as a percentage of the previous measure; iii) change in the proportion of adults diagnosed within each BMI category and the variation in the relative and odds risk ratios of chronic energy deficiency (CED) defined using BMI <18.5. To accurately evaluate the impact of weight change on BMI the repeated adult height measures were averaged. Each of the derivations were analysed by gender and where sample size permitted by discrete period of adulthood.

Crude weight, height and MUAC changes are unsuitable indicators for children due to interaction of age. Rather growth rates, weight and height velocities for age were considered acceptable parameters for assessing seasonal pressures on the energy metabolism of children. In addition the change in HAZ, WHZ, WAZ and BMIZ were used to evaluate child growth performance. Four parameters were used to provide an estimate of the change in child nutritional status between each 4-monthly observation period: i) absolute deviations in weight, height, MUAC and BMI expressed in kilograms and centimetres; ii) relative change in weight, MUAC and BMI expressed as a percentage of the previous measure; iii) change in the height-for-age (HAZ), weight-for-age (WAZ), weight-for-height (WHZ) and BMI-for-age (BMIZ) Z-scores; iv) change in the proportion of children diagnosed with adequate nourishment or mild, moderate, severe stunting, underweight, wasting and thinness and the variation in the relative and odds risk ratios of stunting, underweight, wasting and thinness defined using - 2SD. Each of the derivations were analysed by gender and, where sample size permitted, by discrete period of childhood.

The timing between measurements ranged between 106-130 days. To check for significance within subject interval differences a series of repeat measures analysis of variance models were used to compare the unadjusted and adjusted delta weight, height and MUAC measures. No significant differences were observed.

3.4.6 Data - Independent Variables: The independent variables were divided into three hierarchical levels: individual, household and community.

Individual level: The first set of exogenous variables are related to the individual. Table 3.10 lists individual level variables by domain (demographic, health status, nutrition). The number of variables included within the individual level analysis was dependent on age since there were specific variables related to pre-school and school children. The majority of variables related to pre-school children were copied directly from the child's health card these included: place of birth (type of facility), birth weight, birth length, immunisation status, utilisation of growth monitoring (Figure 3.3a and 3.3b show photocopies of the front and inside of a fictitious Zimbabwean child health card.

Household level variables: the second hierarchical level of independent variables included: household size, dependency ratio, gender, age and education level of household head, household food security indicators, number of meals per day, dietary quality indices, household socio-economic status and wealth index. Environmental indicators included: type of dwelling and access to sanitation and potable water. Distance estimates to various types of formal health-care facilities and markets were also included as indicators of access to institutions.

Gender of household head: Empirical analysis has highlighted the importance of the gender of the household head in ensuring adequate household nutritional status. However, differentiating between male and female headed households is difficult since the definition differs depending on who is defining it and the objective of the definition. The standard survey definition refers to *'the member of the household who is recognised as such by the community and other members of his/her household'*. The common interpretation of this definition relates to the 'traditional' connotations associated with a 'self-declared' household head often used as a proxy for income control. This definition has its limitations as it overlooks the dimension of residency. In this thesis a household head was defined as the member responsible for the day to day decision making and the allocation of resources that could affect the household nutritional status. In cases where the male head of household was absent for two or more study periods the household was classified as female headed. Female headed households were further divided into two groups: *de facto* and *de jure*. *De facto* female headed households (those where the male head was absent for at least 50% of the time) and *de jure* female headed households, where the husband was deceased or the couple were divorced.

Household size: refers to the number of household members physical resident.

Dependency ratio: For comparative purposes the dependency ratio was computed using the same formulae used by Zimbabwean Census 1992 and ZDHS 1994. The *de facto* population was divided into three broad age groups, dependants were defined as children <15 years and elderly ≥65 years. Hence, the dependency ratio was defined as the sum of all dependants divided by the number of persons aged between 15-64 year olds who were considered potential income earners and carers, expressed as a ratio.

Food security indicators: included three measures, number of meals per day and Food Variety Score (FVS) defined as the total number of foods items consumed by the household more than three times per week during the previous 4 months and a Dietary Diversity Score (DDS) defined as the number of food groups consumed by the household more than three times per week. The latter indicator was modified from Kant *et al.*, (1991 and 1995), the score included eleven food groups: cereals, roots/tubers, legumes/seeds, green leafy vegetables, other vegetables, fruits, meat/fish, insects, dairy products, fats and oils , sugars/sweets. The maximum score was 11, one point for each group consumed during the 4-month period.

Estimation of household socio-economic status (SES): Several indicators were used to estimate the socio-economic status of the sampled households in order to capture the multi-dimensional nature of the construct of poverty and the vulnerability and resilience levels of the household. The measures of socio-economic status were related to the following main categories: total income, number of income by sources, remittances, size of land holding, monetary value of total livestock holding, crop production and number of agricultural and household assets.

The socio-economic status (SES) of the household sample was classified into three categories: 'very poor', 'poor' and 'non-poor'. This classification was obtained by comparing the household's estimated annual *per capita* income with the minimum income required to sustain physical existence. Two income cut-off points or poverty lines were used namely, the Food Poverty Line (FPL) and Total Consumption Poverty Line (TCPL). The FPL is defined as the level of income at which the population household can meet their basic food needs whereas the TCPL refers to the level of income the population requires to meet their basic food and non-food needs such as housing, health-care, education, transport and clothing. If the household's *per capita* income is less than the FPL they are classified as 'very poor', if the household's *per capita* income is more than or equal to the FPL but below the TCPL they are classified as 'poor'. Household's with a *per capita* income above the TCPL are categorised as 'non-poor'. The respective monetary values used for the FPL (Z$1,290.64) and TCPL (Z$2,103.74) were considered relevant as they had been specifically devised for Buhera District using the data obtained in PASS report (MPSLSW, 1995). A poverty assessment survey which had been conducted at the same time as the Buhera study.

Indicators used to assess access and utilisation to formal health-care and markets: Distances expressed in kilometres to the nearest district hospital, rural hospital, rural clinic and outreach post and market were estimated for each household using a global positioning system (GPS).

Computation of environmental indicators

Type of dwelling: The classification of a dwelling was based on the material used for construction of the walls, floor and roof. Applying the criterion used by the 1992 Census and 1994 PASS reports a traditional unit consisted of a pole, dagga/bricks with a thatched roof; a modern unit was defined as cement flooring and zinc roof, and a mixed unit had a mixture of the above materials listed.

Water potability: Empirical evidence has established important links between the provision of potable (clean) water within reasonable distance and nutritional status. Protected water sources included (pipe, well or bore-hole) and unprotected sources included (unprotected well, rain water and river/stream).

Sanitation: A properly constructed and used toilet reduces transmission of disease. The study obtained information related to access rather than usage of toilet. Households indicated the type of toilet system they used if any.

Community level variables: the third hierarchical level of independent variables was community level. The three indicators generated during the sampling strategy namely, agro-ecological zone at ward level, health-care access at Vidco level and potable water access at village level were used as community level estimates of food, health-care and the environmental situation.

3.5 Statistical Analyses

All continuous variables were first checked for normality using the Cox test for skewness (Snedecor & Cochran, 1989). Where normalising was not possible both parametric and non-parametric tests were used and the mean and median values are reported. All statistically analyses were carried out with the statistical package SPSS 9.0 for Windows. Statistical tests used within the thesis include correlation, one-way analyses of variance (ANOVA), bivariate, linear and multiple regressions for normally distributed continous variables; chi-square and logistic regression for categorical variables. Non-parametric tests used included: Mann-Whitney, Kruskal-Wallis, Wilcoxon matched pairs signed rank test, McNemar's matched pairs and Spearman rank correlation. Gender differences were examined using independent tests and age differences were explored ANOVA with a *posteriori* tests. Multi-regression analyses were used to examine the effect of age and gender on each anthropometric measure. The relationship between growth velocity and initial growth status was determined using multiple regressions on HAZ, WHZ and BMIZ, age was entered as a covariate to control for the higher growth velocities observed during infancy and puberty. Variation in the prevalence of CED, stunting, wasting underweight, and thinness was tested using chi-square analyses. These analyses were disaggregated by gender and each discrete period of adulthood and childhood where sample sizes permitted. The impact of age and gender on growth status was ascertained with one way ANCOVA and multiple regression. In multiple regression analyses attention was given so that the ratio of number of cases to independent variables never reached the limit defined by $N \geq 50 + 8m$, where m is the number of dependent variables, for testing multiple correlations, and $N \geq 104+m$, testing individual predictors.

The presence, extent and severity of nutritional seasonality was examined by comparing the 3 or 4 repeat anthropometric measures taken in Nov-94, Mar-95, Jul-95 and Nov-95. The change was examined by subtracting the measures from the beginning and end of each season. For example, change in nutritional status in the *pre-harvest* was assessed by subtracting the measures taken in Mar-95 from those taken in Nov-94. Similarly, the *harvest* period was examined by (subtracting Mar-95 from Jul-95) and *post-harvest* by (subtracting Jul-95 from Nov-95). A mixed design repeated measures analyses of variance was used to establish significant within and between subject seasonal variation for the observed absolute differences in mean weight, BMI, MUAC, HAZ, WHZ, WAZ, and BMIZ between survey rounds. In each set of analyses the Mauchly's W test was highly significant indicating that the assumption of sphericity had been violated. One of two correction factors (epsilons) was applied to produce a valid F-ratio depending on the degree of sphericity observed. In cases where sphericity <0.75 the Greenhouse-Geisser epsilon was used; on the occasions when sphericity ≥0.75 the Huynh and Field epsilon was applied (Field, 2000).

In any study where there are multiple significance tests, some results may be significant by chance alone. While levels of significance are reported in the thesis, those with higher significance levels ($p<0.005$ or $p<0.001$) are more likely to represent real differences. In addition, the Bonferroni correction was used to minimise significant results. This correction is obtained by dividing a minimum significance level by the number of comparisons made. For example, if there are five comparisons, the observed significance level for the original comparison must be less than 0.01 (0.05/5) for the difference to be significant (Bland, 1995).

3. 6 Summary

1. This chapter provides details of the conceptual, empirical and analytical frameworks of the Buhera study.
2. The food, health and nutrition study was conducted in Buhera District, a food deficit area considered at high risk of seasonality.
3. A conceptual framework of chronic malnutrition was developed to outline the proximate individual level factors, underlying or distal factors mediated by the household and basic conditions at the community level that could effect nutritional status in Buhera.
4. The study protocol, designed to represent three key periods during the agricultural cycle: *pre-harvest*, *harvest* and *post-harvest* periods, was described and illustrated by use of calendar.
5. A stratified multi-stage cluster sample strategy was implemented. A total of 354 households were selected to participate; all depended on rain-fed agriculture.
6. Ten enumerators and three nurses were recruited and trained for various components of data collection. Two data entry clerks were hired and trained to use the relational database.
7. All research instruments used in the study including the anthropometric measurements and questionnaires are detailed.
8. Derivation of the anthropometric indices and demographic, food security, morbidity, socio-economic status and environmental indicators are outlined.

Chapter 3 - Tables, Figures and Maps

Description	Zone III	Zone IV	Zone V
Annual precipitation	600-800mm	450-600 mm	<450 mm
Recommended land use practices	Semi-intensive cropping & livestock production	Semi-extensive cropping and livestock production	Extensive livestock production only
Percent of land in Zimbabwe	19%	38%	27%
Percent under communal farming	43%	62%	45%
Grading of climatic seasonality	Moderate to Severe	Severe	Severe

***Table 3.1**: Descriptions of agro-ecological zone and grading of climatic seasonality Modified from Zimbabwe Ministry of Agriculture (MOA)*

Strata	Stratified	Cluster	No. HHs	No. Pop.
District			38 917	203 739
Wards	Agro-ecological zones: III, IV & V	Random, proportional to distribution of Pop.	845-1531	4102-8337
Vidcos	Access to health clinics	Random, proportional to No. Good/bad	100-150	520-780
Villages	Access to potable water	Random, proportional to No. Good/bad	20-30	104-156
Households	Not stratified	Random		5.2

***Table 3.2:** Approximate population size of each strata, stratifiers and cluster used in the Buhera study sampling strategy*

Type of Facility	Rating for Services	No. days services available/month	Final weight (Rating*Freq)/30
Hospital	7	30	7
Rural Hospital	5	30	5
Clinic	5	22	3.7
Outreach	1	1	0.033

***Table 3.3** Weighting factors for health centres*

Water Source	Weighting	Description
Borehole	10	Water sources with pumps
Deep well	9	Water sources made by Christian Care or the DDF which are not drilled
Open well	5	Any well not falling into the other three categories
Family well	6	Wells at homesteads which are not used by the community as a whole.

***Table 3.4**: Weighting factors for water sources*

STRATA	Total No.	No. HHs	No. Pop.	No. selected in study	Proportion of total selected
District	1	38 917	203 739		
Wards	30	845-1531	4102-8337	10	33.0%
Vidcos	180	100-150	520-780	20	11.1%
Villages	1080	20-30	104-156	60	5.6%
Households	38 917		5.2	360	0.9%
Population	203 739				

Table 3.5: *Probability of estimate by strata*

Gender	Age (yrs.)	W/A Z-scores	H/A Z-scores	W/H Z-scores	BMI
Male	<1	0.34	0.70	0.76	0.67
Female	<1	1.58	2.18	0.76	1.15
Male	1-5	2.30	1.45	1.77	1.43
Female	1-5	1.00	1.56	2.27	1.32
Male	6-9	1.37	1.03	1.11	1.72
Female	6-9	1.66	1.20	1.35	1.14
Male	10-17	1.11	0.74	1.78	1.27
Female	10-17	1.04	1.03	1.39	0.88
Male	18-21				0.43
Female	18-21				1.75
Male	22-49				0.85
Female	22-49				0.90
Male	≥ 50				0.72
Female	≥ 50				1.63

Table 3.6: *Estimate of design effect of sampling strategy using agro-ecological zone as strata and ward as the cluster using Mar-95 anthropometric measures*

Survey Period	*One*				*Two*				*Three*			
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average High Temp.(°C)	29-31	28-30	26-28	26-28	26-28	25-27	24-26	22-24	20-22	20-22	22-24	26-28
Average Low Temp. (°C)	13-15	14-16	26-28	15-17	15-17	14-16	11-13	8-10	5-7	55-7	6-8	10-12
Average rainfall (mm)	30-35	95-100	155-160	135-140	130-135	80-85	25-30	5-10	<5	<5	<5	5-10
Climate			← Rainy, hot →							← Dry, rainy→		
Period			*Pre-harvest/hungry period*					Harvest			Post-harvest	
Maize cycle												
Sorghum cycle												
Estimate quantity food available	++	+	+	+	+	+	+++	+++	+++	+++	+++	++
Estimate quality food available	++	++	+++	+++	+++	++	+	+	+	+	+	+
Energy demand	++	+++	+++	+++	++	++	++	++	+	+	+	+
Diseases		Me	D	D	D Ma				R	R	R	

Table 3.7: *Calendar of the predicted seasonal cycle in Buhera District devised from various secondary data sources. Including: Zimbabwe Ministry of Health Database Infectious diseases and growth monitoring. Crop calendar adapted from FAO 1997. Dietary information sourced from Campbell, 1986, Benhura and Chitsiku, 1990, 1991, Zinyama et al 1990*

Key:

Agricultural activities	Diseases	Ratings
Ground preparation, planting	D - Diarrhoea	+ Low
Weeding, Hoeing	Me - Measles	++ Medium
Harvesting	Ma - Malaria	+++ High
	R - Respiratory	

Survey Round	Month	Questionnaire	Stress
1	Oct-94	Demographic RI Household Assets & Income RI	
2	Nov-94	Food Consumption (24 hr recall, Food Freq. RI) Health Status RI Anthropometric Trial Survey	Food/Health/Energy
3	Jan-95	Household & Agricultural Asset Price RI	
4	Feb-95	Food Flows RI Off-farm & Livestock Income RI	
5	Mar-95	Food Consumption RII Anthropometric RI	Food/Health/Energy
6	May-95	Crop Production RI	
7	Jun-95	Food-Flows RI Off-farm & Livestock Income RII	
8	July 95	Food Consumption RIII Health Status RIII Anthropometric RII	Optimum
9	Sept. 95	Demographic verification RII Household & Agricultural Assets RII	
10	Oct. 95	Food Flows RIII Off-farm & Livestock Income RIII	
11	Nov. 95	Food Consumption RIV Health Status RIV Anthropometric III	Food/Health/Energy

Table 3.8:*A summary of the final household field survey schedule*

Age group	Age (years)	Age (months)	Description of Population
1	0 - 4.99	< 60	*Pre-school/Under five's*
2	5 - 9.99	60-119	*Middle-childhood/Primary school-aged*
3	10 - 17.99	120-215	*Adolescents*
4	18 - 21.99	216-263	*Young adult*
5	22 - 59.99	264-599	*Adults*
6	≥ 60	≥ 720	*Elderly*

Table: 3.9 *Age class division used for cross-sectional and longitudinal analysis of anthropometric data*

Variable level/type/name	Description
Demography	
AGEYR	Age expressed in years
AGEGRP	Age group e.g. pre-school; elderly
GENDER	Gender
MARITAL	Marital status
EDUCLV	Education level (years)
EDUCAT	All educational category
EDUCYBIOM	Biological mother's level education
EDUCYBIOD	Biological father's level education
EDUCHG	Children's change in education level
RELHHH	Relationship to household head
BIRTHOR	Birth order
RELIGON	Religious affiliation
INCACT	Principal income activity of HH/head
RESTAT	Resident status
Health status	
ILLYN	Ill during the previous 2 weeks
ILLNDYS	Number of days ill
ILLTYP	Symptoms of illness
Under five's	
BIRTHPL	Place of birth
BIRTHWT	Birth weight
BLENGTH	Birth length
AGEWEAN	Age weaned (months)
IMMUNST	Immunisation status
GROWTHM	Utilisation growth monitoring
FREQFED	Average times fed per day during last 4-months
Adult female	
PARITY	No. children
Demographic	
GENHHH	Gender of household head
DEFACTO	*De-facto* & *De jure* female headed & Male
TYPFAM	Social arrangement
DPRATIO	Dependency ratio
HHSIZE	Household size
APOLSTL	Apolstolic religion

Table 3.10: *List of individual level anthropometric status, demographic, health, variables*

Variable level/type/name	Description
Socio-economic status	
INCOMCD	Income category, based on FCLP & TCLP
TERCILES	HH-SES based on sample income division terciles
ENUMCL	Enumerator classification of socio-economic status
NINCSOU	No. income sources
EDUCATHH	Educational level household head
ASETHH	Number of household assets
ASETAGR	Number of agricultural assets
Animal stocks	
CHERD	Size of cattle herd
GHERD	Size of goat herd
DRAFT	Accesss to draft cattle
Agricultural production	
LANDPCH	Number of hectares planted *per capita*
CROPATRN	Cropping pattern
GARDEN	Access to garden
GRAINST	Access to grain store
Food consumption	
NMEALS	Number of meals per day
NFOOD24	Number of unique foods - 24 HR
NFGRPS24	Number of food groups
DIETPAT	Dietary pattern
HENERGY	Consumed oil and sugar
NFOODFFQ	Number of unique foods - FFQ
NFDSOUR	Number of food sources
WILDFDS	Used wild food sources
Environmental characteristic	
DWELTYP	Type of dwelling
SANITAT	Access to sanitation
WATERS	Water source
WATERP	Water source protected
Distance	
DISCLINC	Estimated distance to nearest clinic
DISHOSP	Estimated distance to nearest hospital
REMOTE	Enumerator classification of remoteness
DISMARKT	Estimated distance to nearest market
Community level	
AGROZN	Agro-ecological zone - Ward level
HEALTHA	Health access - Vidco level
WATERAC	Water access - Village level

Table 3.11: *List of household level demographic, food, health, socio-economic and environmental variables*

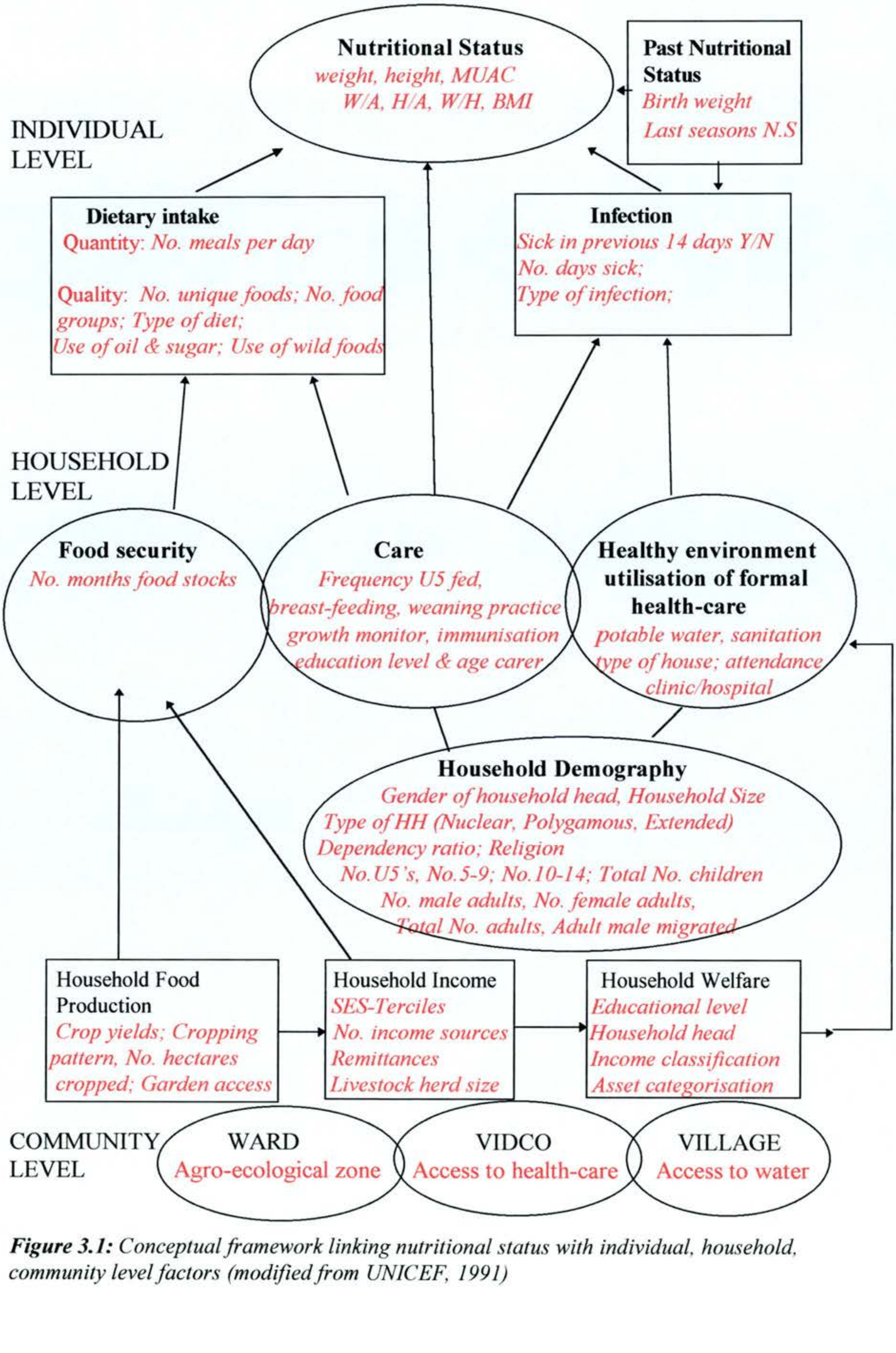


Figure 3.1: *Conceptual framework linking nutritional status with individual, household, community level factors (modified from UNICEF, 1991)*

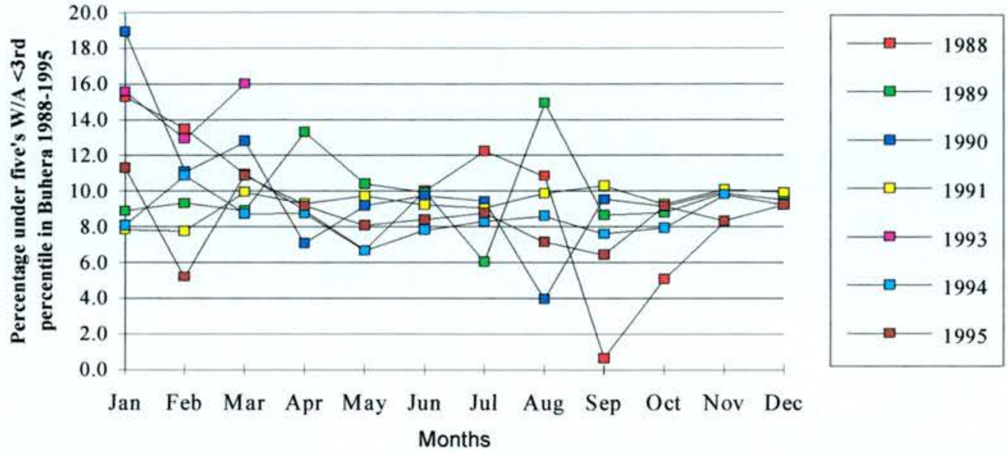
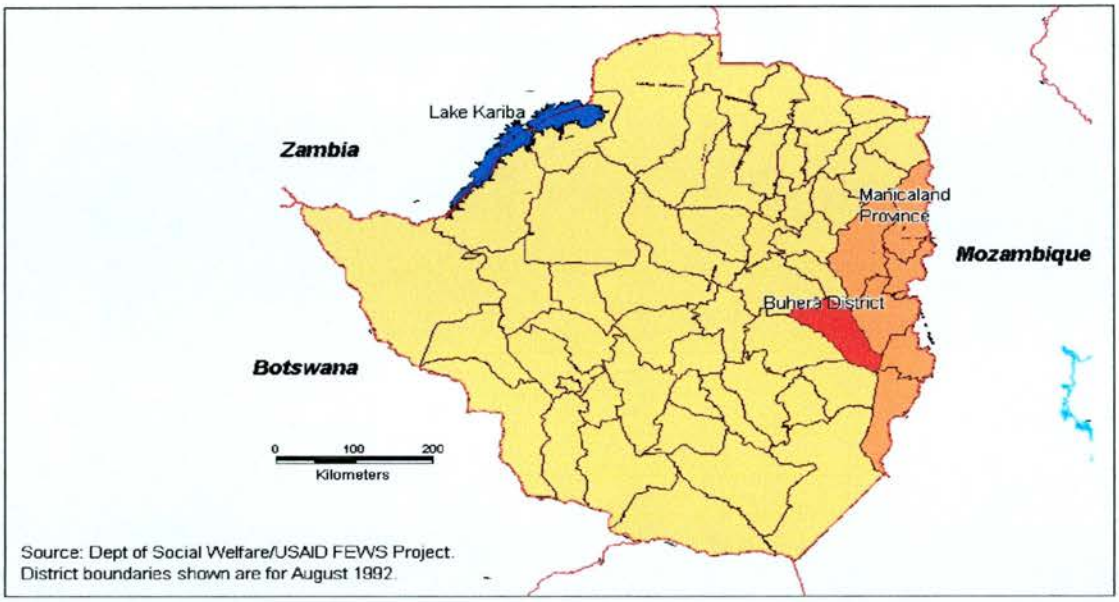
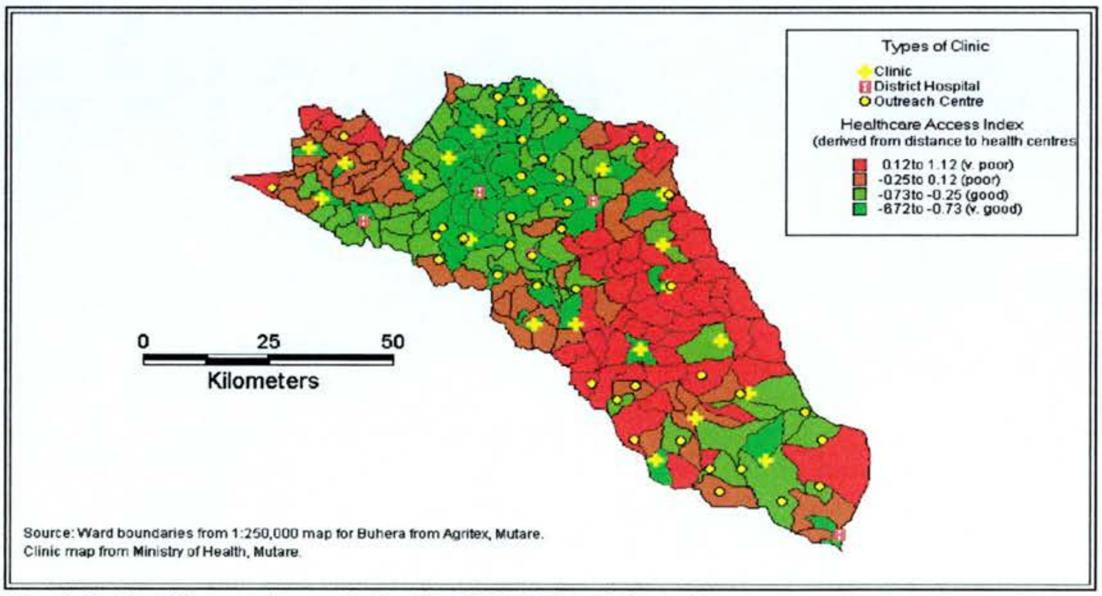


***Figure 3.2**: Seasonal variation in the prevalence of underweight amongst under five's attending growth monitoring clinics in Buhera District between 1988-1995*

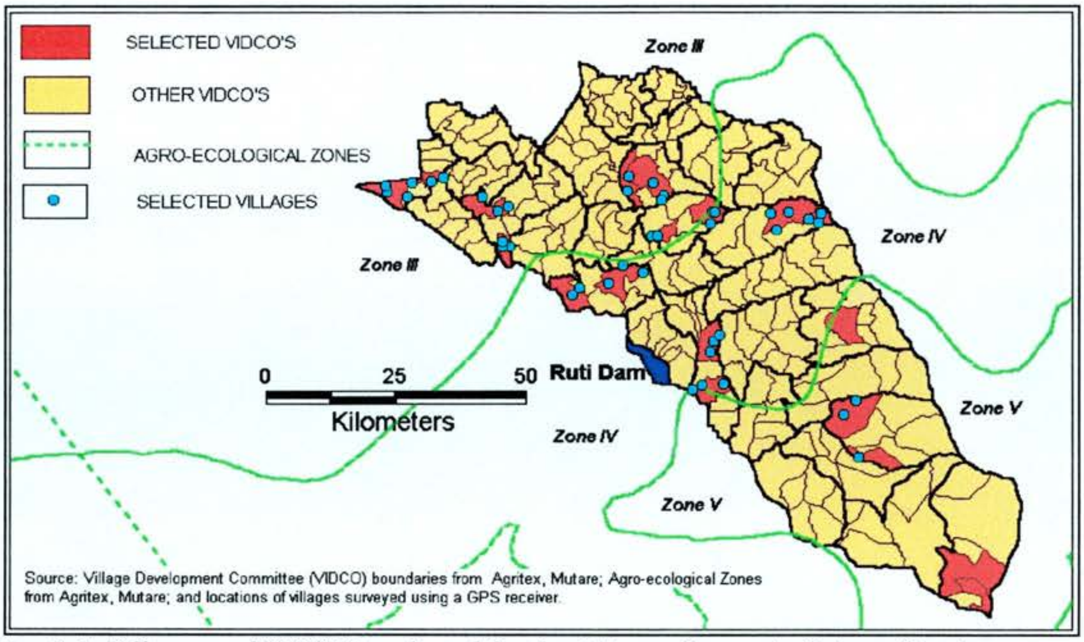
Maps - Chapter 3



Map 3.1: *Location of Buhera District within Zimbabwe*



Map 3.2: *Healthcare Access Index by VIDCO for Buhera District*



Map 3.3: *Villages and VIDCO's selected for the Primary Survey in Buhera District*

Photographs - Chapter 3

Photo 2: *Mucavele, P.J. (1995) Portable Wooden Measuring Board*

Photo 3: *Mucavele P.J. (1995) Rollameter used to measure infants in Buhera Study*

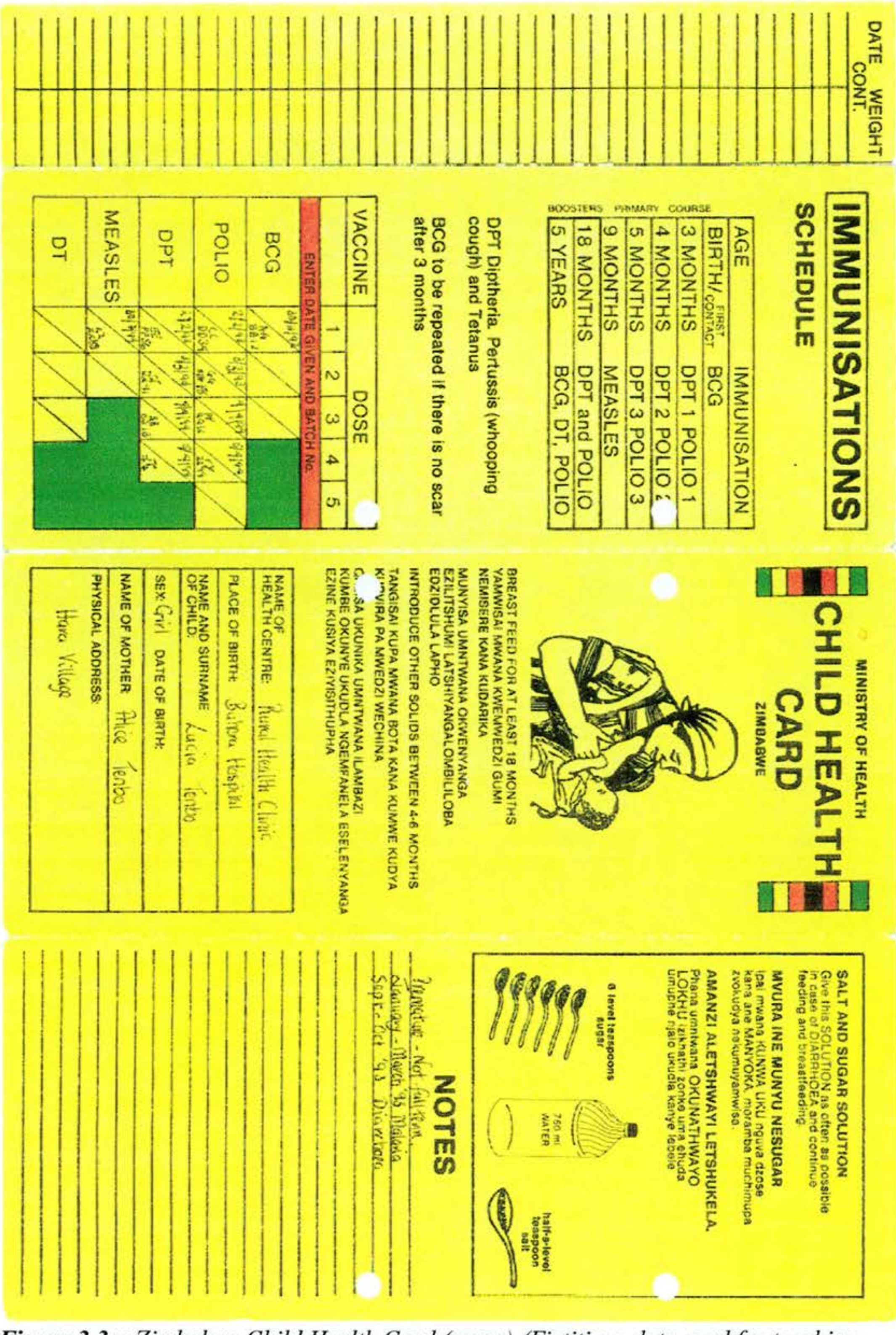


Figure 3.3a: *Zimbabwe Child Health Card (cover) (Fictitious data used for teaching purposes).*

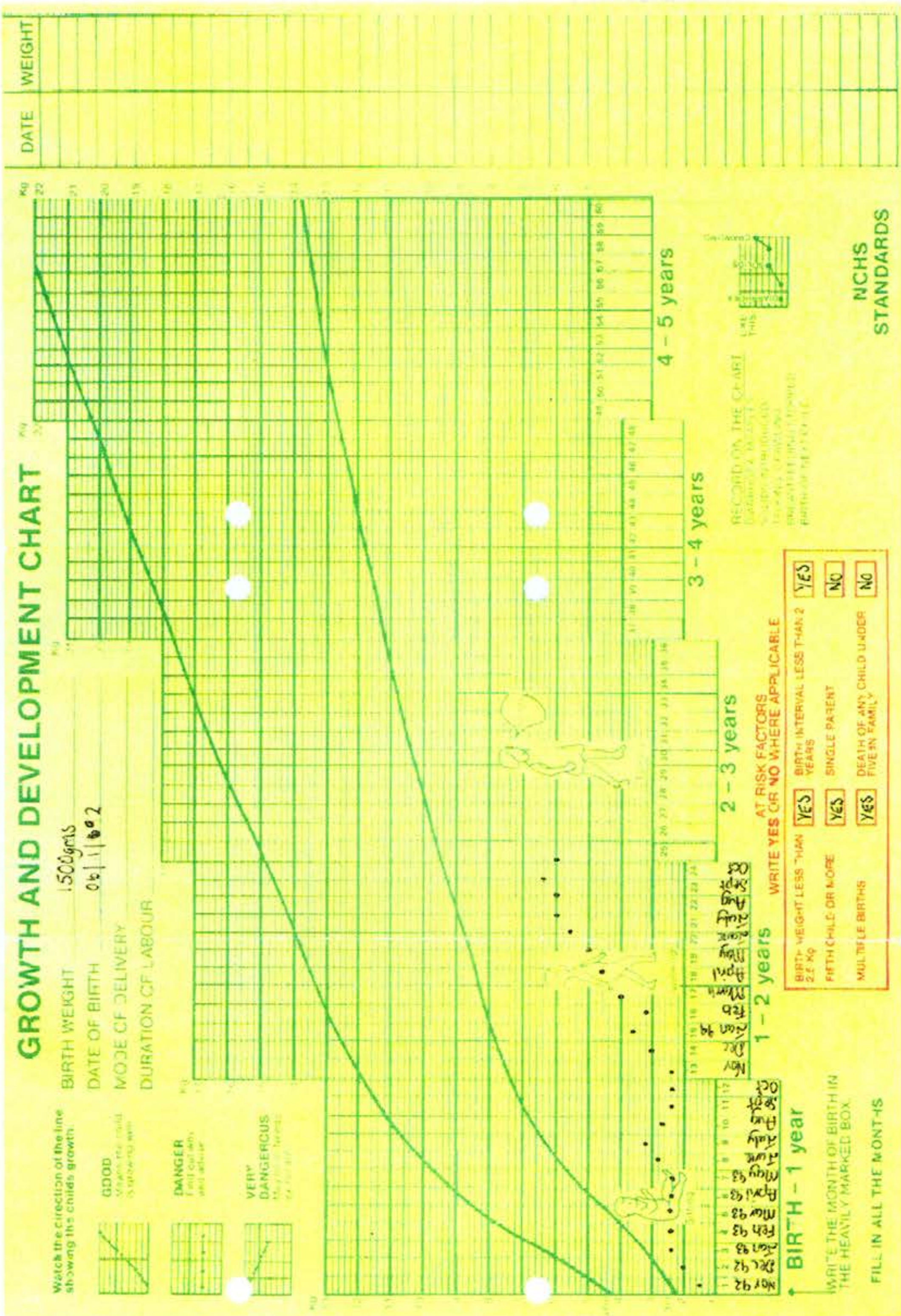


Figure 3.3b: *Zimbabwe Child Health Card (inside) (Fictitious data used for teaching purposes).*

CHAPTER 4 HOUSEHOLD CHARACTERISTICS AND DEMOGRAPHIC PROFILE OF THE POPULATION

4.1 Introduction

This chapter describes the main demographic, socio-economic and environmental characteristics of the selected households, outlines the demographic profile of the household population, compares the demographic and socio-economic characteristics by agro-ecological zone, socio-economic status and gender of the household head. The association between the household level factors described in this chapter and nutritional status of different household members is presented in Chapter 7.

4.2 Description of household sample

4.2.1 Household attrition: A total of 354 households were original selected but due to migration, death, and refusal to participate the number of households participating in each survey round fluctuated. Half the sampled households answered all 26 questionnaires, 300 (85%) of the household answered ≥21 (80%) of the questionnaires. The overall attrition rate for the whole study was relatively low 5.6%. Of the 20 households who dropped out, 13 moved from the District, six had a death and one refused.

Generally, the variable participation rates between survey rounds were attributed to the transient nature of the households. Temporary movement away from the District was particularly high during the winter months (Jun-Sep) after harvest when it was common for spouses to visit their remitting husbands or seek alternative employment. Appendix 2-Table 4.2.1 summarises the participation and attrition rate by questionnaire and survey month. The subsequent cross-sectional analysis of demographic characteristics has been based on 349 households that answered the first demographic questionnaire. Six of the households with baseline demographic data had insufficient data over-time to provide a reasonable estimate of annual *per capita* income. Hence, the comparative analysis by socio-economic status uses income data based on the responses from 343 households. The longitudinal analysis used to capture seasonal changes in demographic characteristics, socio-economic status and environmental conditions varies in size depending on the number of repeat questionnaires answered.

4.3 Demographic characteristics of the household sample

Of the 349 households with baseline demographic data, 158 (45.3%) were monogamous residing as a nuclear family, 144 (41.3%) lived as an extended family, 41 (11.7%) were polygamous and the remaining six (1.7%) were of single occupancy. Each spouse of polygamous households was interviewed separately as though they were living as a separate economic unit. Of the polygamous households, 33 (80.5%) contained two wives, 4, (9.8%) three wives, 3 (7.3%) four wives and one (2.4%) had was comprised of five wives. The polygamous households were merged after retrospective analyses found that they were functioning as one single consumption unit sharing resources[1].

4.3.1 Distribution of the household sample by gender of the household head:

Over half, 192 (55.0%) households were male headed, 107 (30.7%) were *de facto* female headed and 50 (14.3%) were *de jure* female headed. Hence, female headed households account for 45.0% of the sample, 6.0% higher than the proportion reported in the 1994 Zimbabwean Census. Of the 50 households, classified as *de jure* female headed, 41 (82.9%) were widowed and 9 (18.0%) were divorced.

4.3.2 Classification of socio-economic status (SES) of household sample:

Households were classified as either 'very poor', 'poor' or 'non-poor'. The SES classification was obtained by comparing the household's estimated annual *per capita* income with the minimum income required to sustain physical existence. Details of procedure used to categorise the SES of the sampled households is given in the methodology (see Chapter 3). The majority, 301 (87.8%) of the 343 households with an estimate of annual *per capita* income were categorised as 'very poor'; these households are also considered 'food insecure' as the annual *per capita* income was less than that required to purchase a minimum food basket. Twenty-five households, 7.3% of the sample were classified as 'poor', and 4.9% were considered 'non-poor'. The head count index, that is the proportion of households below both the Food Poverty Line (FPL) and Total Consumption Poverty Line (TCPL) was estimated to be 0.95, this was 6% higher than the proportion estimated for Buhera District by the PASS 1995 (MPSLSW, 1996). An alternative internal classification of household SES was also computed to improve the frequency distribution of households between each income category. Households were divided into three equal groups based on annual *per capita* income.

No association was observed between household SES assessed using the PASS income categorisation and gender of household head. In contrast, a highly significant association was observed between household SES using the internal tercile classification and gender of the household head ($p<0.001$). Over half (51.4%) the *de facto* female headed households were categorised in the upper income tercile compared to only one in four of the male headed (25.7%) and *de jure* female headed households (23.4%). Not quite half (42.6%) *de jure* female headed households, over a third (38.7%) male headed household and less than a fifth (19.0%) of the *de facto* female headed households were classified in the lower income tercile (Table 4.3.1).

The significant variation in the distribution of household SES by agro-ecological zone established using the PASS SES classification remained when the internal SES was used; the pattern was also similar ($p<0.001$). The proportion of households categorised as 'very poor' increased linearly as the potential of the agro-ecological zone to produce crops declined ($p=0.002$). In zone III just over three-quarters (78.3%) of the households were categorised as 'very poor', whereas in the drier zones IV and V, the proportion increased to 88.4% and 97.0%, respectively (Table 4.3.2). Over half (53.5%) the households located in agro-ecological zone V were categorised in the lower income tercile whereas nearly half (44.3%) the households in zone III were classified in the upper income tercile (Table 4.3.2).

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[1] All consumption, expenditure, income and resource data was pooled except in circumstances where it was obviously duplicated.

4.3.3 Household size: Household size ranged between 1-23 occupants; the sample was highly right skewed. The skewness was removed and the number of occupants was reduced by half to between 1-12 when the polygamous households were omitted from the analysis. Median number of occupants was 5.0 irrespective of the whether the polygamous households were included or excluded from the analysis. Mean household size including the polygamous households was 5.7 ± 3.0 members; excluding polygamous households the mean was 5.1 ± 2.2 members. The latter estimate was closest to the 5.2 estimate for household size reported for Buhera District in 1992 Population Census (CSO, 1994).

Due to significant positive skewness in household size, both the mean and median were used for comparative purposes. The mean size of male headed households (6.7 ± 3.3 members) was significantly larger than *de facto* (4.6 ± 2.1 members) and *de jure* (4.2 ± 2.1 members) female headed households ($p<0.001$) (Table 4.3.4). The Games-Howell *a posteriori* test suggested that there was significant heterogeneity between male headed households and both *de facto* and *de jure* female headed households. On average *de facto* female headed households were slightly larger than *de jure* female headed households but the difference between the two types of female headed households was statistically insignificant. The median size of male, *de facto* and *de jure* female headed households were rounded to 6.0, 4.0, and 4.0 respectively. The absolute difference between male and female headed households is evident; the values suggest that male headed households are a third larger than female headed households ($p<0.001$) (Table 4.3.4).

There was also a significant association and linear trend between household size and socio-economic status ($p=0.001$). The mean size of households categorised as 'very poor' was (5.9 ± 3.1 members), for 'poor' (4.8 ± 2.5 members) and 'non-poor' (3.6 ± 1.3 members). The Hochberg's GT2 *a posterior* test suggested there was significant heterogeneity between the size of 'very poor' and 'non-poor' households (Table 4.3.5). This pattern was mirrored when the internal household SES classification was applied although the variation in mean household size between the income terciles was slightly less it remained highly significant ($p<0.001$). The mean household size for lower, middle and upper income tercile were 6.9, 5.7 and 4.6, respectively. There was a tendency for household size to increase as the potential of the agro-ecological zone decreased. However, the association between agro-ecological zone and household size was statistically insignificant (Table 4.3.6). It is evident from the results that there is a large variability in household size. One way of attempting to correct for this is to divide household level resources by the number of members. *Per capita* estimates are used within this thesis to provide comparable indicators between households.

4.3.4 Household composition: In terms of household composition, there was a highly significant variation in the number of adult men across household types. On average, there was less than one (0.7) adult male per household; even though the variance between households was high. There was just over one adult male in male headed households whereas there were 0.2 and 0.3 adult males in *de facto* and *de jure* female headed households. Polygamy accounts for the relatively higher mean number of adult women within male headed households compared to *de facto* female headed households.

On average 'non-poor' households, have fewer male adults compared to the 'very poor' and 'poor'. This infers how the absence of male adults may increase the household's SES either through remittances, as the 'missing' male adults are generally involved in alternative off-farm employment out of the district or through a subsequent decrease in household consumption units. The reasons for the prevailing gender ratio within the *de facto* household population are discussed in section 4.8. The number of adult women did not vary significantly between households of different SES. However, there were significantly more children in 'very poor' households compared to the 'non-poor' households ($p<0.001$) (Table 4.3.5a). These results were emulated using the internal classification of SES. Household in the lower income tercile were on average significantly larger and had twice as many children aged <15 years old as households within the upper income tercile (Table 4.3.5b).

The mean number of adult males and females per household did not vary by agro-ecological zone. The main difference in household composition by agro-ecological was the number of children. On average, the drier zone V had one child more per household than those in zone III (p=0.009) (Table 4.3.6).

4.3.5 Dependency ratio: There was also a large variation in the number of dependants (children <15 years and elderly ≥60 years) per potential income earner; the dependency ratio ranged between 0-6. Due to relatively high coefficient of variance (CV) (66.0%) both the mean and median dependency ratios were used for comparative purposes. The mean dependency ratio was high, 2.0 ± 1.2 suggesting that for every potential earner or carer there were two dependants. The mean dependency ratio of *de jure* and *de facto* female headed households (2.1 ± 1.2) was slightly higher than male headed households (1.9 ± 1.7) although the difference was statistically insignificant (Table 4.3.4).

There was significant heterogeneity between household SES and mean dependency ratio (p<0.001). The mean dependency ratios of the 'very poor', 'poor' and 'non-poor' were, 2.0 ± 1.2, 1.3 ± 0.9 and 1.5 ± 1.0, respectively (Table 4.3.5a). Likewise, lower income tercile households (2.3 ± 1.1) had significantly higher dependency ratio compared to upper income tercile (1.6 ± 1.1) (Table 4.3.5b). Households located in the drier agro-ecological zone V had a slightly higher dependency ratio compared to households situated in zone III and IV but the difference was statistically insignificant (Table 4.3.6). Since, the dependency ratio is assumed to be inversely correlated with the availability and quality of time to care, these results suggest that households that were either, 'very poor', female headed or located in agro-ecological zone V may be more nutritionally vulnerable due to the relatively higher dependency ratios.

4.3.6 Age of household head: The mean age of household head was 45.5 ± 16.5 years. *De facto,* female heads were significantly younger than male and *de jure* female heads of household; the median ages were 33.9, 44.9 and 60.4 years, respectively

($p<0.001$). *De jure,* female heads of households tended to be somewhat older than their male counterparts, but the difference was statistically insignificant. The elderly nature of *de jure* female headed households is probably partially explained by the fact that the majority (82%) were widowed. There was no association between household SES and age of household head using either the PASS or internal classification of SES (Table 4.3.5a-4.3.5b). The median ages of the household heads by agro-ecological zone III, IV, and V were 46.1, 39.7 and 42.5 years, respectively. The relationship between agro-ecological zone and the median age of the household head was just significant ($p=0.020$). The slightly younger nature of household head's in zone IV can be accounted for by the higher prevalence of *de facto* female heads (Table 4.3.3). As seen above *de facto* female heads were significantly younger than both male and *de jure* female heads.

4.3.7 Educational level of household head: The number of years of education for the household head was normally distributed ranging between 0-16 years; the mean was 5.4 ± 3.1 years. Using the number of years of education, the education level of the household head was categorised into three levels: no education, primary school (1-7 years) and more than primary school (≥ 8 years). Approximately, two-thirds (65.4%) of household heads' had completed primary education; just over a fifth (22.7%) had more than primary education and 11.9% had no education. There was a significant inverse correlation between the number of years of education and age of the household head ($r=0.57$, $p<0.01$), suggesting that the number years of education decreased with the household head's age (statistics not tabulated). Hence, age of the household head was considered a covariate and controlled for when examining the relationship between education level and other household characteristics.

There was a highly significant association between gender of household head and education category ($p<0.001$). *De jure* female heads were three times more likely to have no education compared to male and *de facto* female heads. Nearly a third (30.2%) of the *de facto* female heads had some secondary education. There was significant heterogeneity observed between gender of the household head and the number of years of education ($p<0.001$). *De facto* female heads had significantly more years of education (6.3 ± 3.0 years) compared to male (5.6 ± 3.1 years) and *de jure* female heads (2.8 ± 2.4 years) in Hochberg's GT2 *a posteriori* test. However, this difference was statistically insignificantly after controlling for the interaction between age and the gender of the household head. These results suggest the significant variation in age between gender of household head explains the significant differences in their level of education (Table 4.3.4).

As expected, there was a significant positive linear association between SES and education level ($p=0.022$), the proportion with education increasing with income. All of the heads of the household's categorised as 'non-poor' had some education whereas 12.2% of the household heads categorised as 'very poor' had no education. Two thirds (66.6%) of the 'very poor' and nearly three-quarters (72.0%) of the 'poor' had some primary school education, whereas over half (52.9%) of the 'non-poor' had secondary education or higher. Non-poor' households on average had 2.5 years more education than either the 'very poor' or 'poor' households although, the relationship between SES and the number of years of education was statistically insignificant after controlling for the interaction with the household head's age (Table 4.3.5a). These results were mirrored using the internal classification of household SES. Although, the relationship was less linear there was a distinct increase in the level of education with each income tercile (Table 4.3.5b).

A significant association was also observed between agro-ecological zone and education category of the household head ($p<0.001$). Household heads located in Zone V were the least educated; over a quarter (27.0%) had no education, compared to 6.8% in Zone III and 5.0% in Zone IV. When examined as a continuous variable, household heads located in Zone V had significantly less years of education compared to household heads residing in Zone III and IV even after controlling for the interaction between agro-ecological zone and age of the household head ($p=0.015$) (Table 4.3.6).

4.4 Socio-economic characteristics of household sample

4.4.1 Diversity of income sources:

Diversification of income sources is a widely adopted coping strategy which is used by subsistent agricultural households as a survival mechanism to meet periodic shortfalls in production. In the Buhera study it was reported that income was obtained from nine different sources: crop sales, livestock sales, off-farm income (salaried or wage labourer), household business (small-scale manufacturing, brick moulding, thatching, pottery, knitting), remittances, gifts from friends, Food-For-Work (FFW), Lobolla (bride price), and pensions.

To provide a measure of annual income diversity the number of income sources by survey period were summed and aggregated for the year. Five percent of the households relied totally on household production (subsistence) reporting that they did not receive any alternative source of income. Not quite half (47.1%) of the households who were reliant on subsistence resided in the higher productive areas; all were classified as 'very poor' and nearly half (47.1%) were male headed. A fifth of the households used one income source throughout the year, just over a quarter (26.8%) had two income sources, a further quarter (24.8%) had three income sources and the remaining quarter (23.3%) used four or more sources.

A significant relationship was observed between gender of household head and income diversification (p=0.004), on average *de facto* female headed households (2.9 ± 1.1) used more income sources than male headed households (2.4 ± 1.1). However, when examined categorically a significantly higher proportion of male headed households (29.3%) were likely to use four or more income sources compared with approximately a sixth of *de facto* and *de jure* female headed households (Table 4.4.2).

The association between household income terciles and income diversity was highly significant (p<0.001). One in eight (12.3%) households in the lower tercile was totally reliant on subsistence agriculture for their income compared to 1.7% of the middle tercile and <1% of the upper tercile. The relationship between agro-ecological zone and income diversity was just significant (p=0.043). The pattern of income diversification was not consistent with the propensity to produce crops. As expected a slightly higher proportion of households located in the higher potential agro-ecological zone III relied on subsistence whereas a larger proportion of households located in the drier zone IV used four or more income sources. However, households located in region V the driest zone surprisingly showed less inclination to diversify their income.

4.4.2 Land: The amount of land owned by subsistent agricultural households is a major asset and one of the main determinants of food security. The number of hectares cropped in the 1993/4 and 1994/5 seasons was computed for each household and expressed in absolute terms per household and in relative terms *per capita*. The mean amount of land cropped per household or *per capita* did not vary significantly between the 1993/4 and 1994/5 seasons. The amount of land cropped ranged between 2.4-2.3 hectares per household, which translated into 0.45-0.43 hectares *per capita*. Significant differences emerged between gender of household head and the absolute amount of land cropped (p=0.002). Hochberg's GT2 *a posteriori* test indicated that male headed households cropped significantly more land than *de jure and de facto* female headed households. These differences were removed after controlling for household size using *per capita* estimates since male headed households were significantly larger than female headed households (Table 4.4.1).

The reverse pattern was observed by household SES and the absolute and relative amount of land cropped. Although, the 'very poor' cropped slightly less land than the 'poor' and 'non-poor' in absolute terms, the differences were statistically insignificant. However, when household size was taken into account the disparity between household SES and amount of land cropped *per capita* became more apparent; the differences were highly significant (p<0.001). Hochberg's GT2 *a posterior* test indicated that the 'very poor' households cropped significantly less land *per capita* than 'poor' and 'non-poor' households (Table 4.4.3a). Similarly, the upper income tercile cropped nearly twice as many hectares *per capita* compared with the lower income terciles (Table 4.4.3b).

The absolute and relative amount of land cropped varied significantly by agro-ecological zone ($p<0.001$). However, there was seemingly limited association between the amount of land cropped and its potential to produce food. Generally, households in the drier semi-arid regions cropped more land due to lower crop yields than those in higher potential densely populated areas where land is scarce. This was the case for households located in region IV one of the semi-arid regions. These households cropped significantly more land than households located in the higher potential area zone III and in the zone V the driest zone; the households in the latter zone cropped the least amount of land ($p<0.001$) (Table 4.4.5).

4.4.3 Agricultural Income: To illustrate the year on year variation in agricultural income in this drought prone area, the value of the 1993/4 and 1994/5 harvests was compared using non-parametric statistics since the distribution of the value of both harvests was not normal. The 1993/4 agricultural season was considered above average whereas the 1994/5 season was declared a national disaster in Mar-95 due to poor rainfall. There was a highly significant decrease in the value of 1994/5 harvest compared to the 1993/4 harvest for households who reported yields and stocks for both seasons (n=273). The median value of the 1993/4 harvest was Z$1,017.70 more than double the value of the 1994/5 harvest Z$467.80. The Wilcoxon matched pairs signed rank test suggested that the value of the 1994/5 harvest was less than the 1993/4 harvest for three-quarters of the households ($Z=8.456$, $p<0.01$). There was a moderately significant positive correlation between the two harvests (Spearman rank: $r=0.424$, $p<0.01$). This result suggests households that had a good harvest in 1993/4 faired best during poorer agricultural season of 1994/5. Of the 316 households, which reported that they had planted during 1994/5 season, a fifth (20.4%) of the 1291 plots planted did not yield any crop. The proportion of plots harvested varied between households, not quite half (48.5%) obtained a yield from all plots planted whereas 22 households (7.0%) did not harvest a single crop (statistics not tabulated).

4.4.4 Crop sales: As expected in a food deficit area very few households sold crops throughout the year. Using the longitudinal sample of households that answered all food flow questionnaires (n=254) it was possible to derive the contribution of crop sales to total household income and examine household behaviour. The number of households selling crops declined as the study progressed, peaking at 14.2% during the *pre-harvest* period Nov-94 to Feb-95, declining to 9.1% during the *harvest* period Mar-95 to Jun-95 and decreasing further to only 4.3% during the *post-harvest* period Jul-95 to Oct-95. This behaviour reflects the poor yields of the 1994/5 harvest.

4.4.5 Remittances: defined as cash or in-kind income received by the household from *de jure* household members; remittances account for a major part of total household income. The proportion of households receiving remittances varied significantly by household types. As inferred by the absent adult men within *de facto* female headed households, the association between gender and household head and receiving remittances was highly significant ($p<0.001$). The majority (91.4%) of *de facto* female headed households received remittances, double the proportion of *de jure* (46.8%) and male (40.8%) headed households. Just over half (53.8%) of the 'very poor' households received remittances; this was a significantly lower proportion compared to 'poor' (80.0%) and 'non-poor' (82.4%) households ($p=0.004$). Similarly, three-quarters (76.3%) of the upper income tercile received remittances, compared with just over a third (39.5%) of the lower income tercile. A higher proportion of households in the drier lower productive areas received remittances, the difference was only just significant ($p=0.050$) (Tables: 4.4.2; 4.4.4*a*&*b*; 4.4.6).

4.4.6 Livestock value and sales: The Shona word 'mupfumi' is the nearest equivalent to the English word of 'wealth'. The Shona dictionary defines 'mupfumi' in relation to livestock this clearly illustrates the importance of livestock in the Shona culture. In drought prone areas like Buhera District livestock are primarily used as assets, but are also an invaluable source of draft power and food. The value of livestock holdings was used to estimate the degree of household vulnerability. It was assumed that households with large numbers of livestock would be more resilient as the livestock holdings could be used as a buffer against any shortfalls created by the poor 1994/5 harvest and thereby avert malnutrition. The majority of households surveyed who answered the livestock question (n=346), 92.8% had at least one type of animal or bird. The monetary value of the household's livestock holding was computed by multiplying the number of each type of animal by its mean market value within Buhera during 1995.

The distribution of value of livestock holding was positively skewed ranging between Z$15.00 - $Z27,685. Both, the mean and median value of the livestock holdings were computed for those households with livestock (n=326). The median livestock value is primarily used as it clearly illustrates the disparity in the value of livestock holdings between different household types. The median value of the livestock holdings of *de jure* female headed households (Z$975.00) was considerably less than both male (Z$2,590.0) and *de facto* female headed households (Z$3,505.0), although the differences were statistically insignificant. The mean value of livestock holdings of *de facto* female headed households was slightly lower whereas the median value was slightly higher than male headed households suggesting that there was more variability in the value of livestock holdings amongst male headed households (Table 4.4.1)

As expected, there were significant differences in median value of livestock holdings by SES ($p<0.001$). The median value (Z$2,400) of the livestock holdings of 'very poor' households was worth approximately a fifth of the 'poor' (Z$10,455) and 'non-poor' (Z$11,477.5). There was seemingly less disparity in the value of livestock holdings between the 'poor' and 'non-poor' (Table 4.4.3a). The divergence in livestock values were even more stark when examined by income tercile. The median value of the livestock holdings of the upper income tercile (Z$7,040.0) was estimated to be 11 times higher than the lower income tercile (Z$600.0) (Table 4.4.3b).

There was also a significant difference in the value of livestock holdings between agro-ecological zones ($p<0.001$). The median values of livestock holdings in agro-ecological zone III, IV and V were Z$5,200, Z$2,900 and Z$1,165, respectively.

There was a distinct linear trend of lower values of livestock holding with decreasing potential of the agricultural land (Table 4.4.5). This trend may be partially explained by the significant variability in the type and value of livestock owned by agro-ecological zone. The mean value of cattle was approximately 16 times higher than goats. Cattle ownership was significantly more prevalent in zone III compared to the drier zones (p=0.008). Over two-thirds (67.7%) of households in zone III owned cattle, compared with 58.8% in zone IV and 45.8% in zone V. In contrast, as expected, goat ownership was more prevalent in the drier agro-ecological zones (p=0.047). Three-quarters (76.0%) of the households owned goats in zone V, two thirds (65.6%) in zone IV and 59.6% in zone III. The pattern of livestock holdings partially explains the observed variance in the value of livestock holdings between agro-ecological zones (Table 4.4.6).

4.4.7 Number of agricultural and household assets: One of the main definitions of wealth in the Oxford dictionary is its relationship to large possessions. Agricultural and domestic assets are frequently used as a proxy or long-term indicator of wealth (CSO, 1995). In addition, the presence or absence of certain possessions such as a plough, scotch cart, bicycle or sewing machine can indirectly increase the household's access to food security. The number of agricultural and domestic assets owned were both positively skewed; the former ranged between 1-12 and the latter between 1-11. There was a significant positive correlation between agricultural and household assets suggesting that households owning large numbers of agricultural assets also owned large numbers of domestic assets (r=0.522, p<0.01) (statistics not tabulated). Generally, the households seemed to own more agricultural assets than domestic belongings. Figures 4.1 and 4.2 illustrate the percentage of households owning each type of domestic and agricultural asset. It is evident from the bar graphs that it was common for households to own small tools (hoe, axe, sickle) and a blanket. Whereas, major agricultural assets and large domestic items were owned by a minority.

There was significant heterogeneity in the mean number of agricultural assets owned by gender of the household head. Hochberg's GT2 *a posteriori* test showed that there was significant difference between *de jure* female headed households who owned the fewest agricultural assets and male headed households who owned the most. In contrast, *de facto* female headed households owned significantly more domestic items compared with both male headed and *de jure* female headed households; median values suggests twice as many ($p<0.001$). Chi-square analysis highlights these differences with over a third of *de facto* female headed households owning a radio and fifth owning a sewing machine compared to only a quarter of male headed households owning the former and 5.8% owning the latter (Table 4.4.2).

As expected there was a significant relationship between household SES and the median number of agricultural assets owned by the 'poor' and 'non-poor' both of whom possessed approximately a third more than the 'very poor' ($p<0.001$). The disparity between the 'very poor' and the 'poor' and non-poor was even greater for domestic items; the two higher income groups owning two-thirds more than the lowest income group. Only a quarter of the 'very poor' households owned a radio compared to a half of the 'non-poor' (Table 4.4.4a). In contrast, the variation in assets ownership was more evident between the upper income tercile which owned on average twice as many domestic products as middle and lower income terciles (Table 4.4.4b). There was also a significant difference in the pattern of asset ownership and agro-ecological zone; the number of assets owned decreased as the zones declined in potential to produce (Table 4.4.5).

4.5 Food security status of the household sample

Food security status of the household sample was assessed from several dimensions including household food availability, food access and food utilisation. It was not possible to accurately evaluate the adequacy of dietary intake in terms of energy or specific nutrients since the estimates were deemed too imprecise. However, it was possible to obtain an impression of dietary adequacy in terms of both quantity and quality using a series of simple indicators computed at the household level to represent each dimension of the food security equation.

4.5.1 Food availability: was assessed using a status quo method comparing cereal yields to *per capita* daily requirements to estimate the sufficiency of grain at the household level. Grain consumption requirements are estimated to be in the region of 230 kg per year or 0.6 kg *per capita* per day. This estimate does not take into account household composition or distribution (SADCC, 1990). The amount of grain *per capita* available from each harvest was computed by converting all yields to kilograms and dividing by the number of household members. This estimate was expressed as kilograms *per capita* and the number of days *per capita* the yield would last based on a daily consumption rate of 0.6 kg. The grains were separated into maize and small grains (millets and sorghum) to provide an estimate of the additional contribution of drought tolerant crops to household security. These grain estimates provide a rather unrefined indication of grain availability. A number of different patterns and trends between households emerged which provide a useful insight into the dynamics of food deficit area. Since, the distribution of the grain estimates was not normal and the coefficient of variation was extremely high both the mean and median values for the various grain indicators are presented.

As discussed earlier there was significant difference in the 1993/4 and 1994/5 harvests. The mean quantity of maize *per capita* harvested in 1993/4 season was approximately double the amount of maize harvested in the 1994/5 season. The median values suggest that the differences were not quite as large. The mean quantity of maize available in the 1993/4 season was 198.0 kg whereas the median was 74.3 kg. The large differences between the two estimates indicate how a few larger producers can affect the mean grain estimates. When the grain estimates were expressed in *per capita* days, the median values suggest that on average households were food secure for only 4 months; this decreased to 2 months during the 1994/5 drought. Growing drought tolerant crops increased the number of months the household was food secure by a month and a half during 1993/4 and a month in 1994/5 season. The importance of drought tolerant crops was most evident when analysed by agro-ecological region (Table 4.5.3).

In general, drought tolerant crops were significantly more likely to be grown by male headed and *de jure* female headed households during 1994/5 season (p=0.011) (Table 4.5.4). The proportion of households growing drought tolerant crops increased with decreasing income (Table 4.5.5a&b) and declining agricultural potential (p<0.001) (Table 4.5.6). These trends were observed in both the 1993/4 and 1994/5 seasons.

4.5.2 Food access: was assessed by summing the number of meals consumed per day, this provided an indication of the quantity of food being accessed by the household. Tables 4.5.1, 4.5.2a&b, and 4.5.3 summarise cross-sectional analyses of the mean number of meals consumed by gender of the household head, SES, and agro-ecological zone, respectively. Figures 4.3-4.5 illustrate the seasonal trend in the mean number of meals consumed by household. The seasonally estimated mean number of meals per day were obtained from repeated measures analysis using the longitudinal sample[2]. The mean number of meals consumed per day declined steadily during the study. On average households reported they consumed three meals per day in the 1994 *post-harvest* season, this decreased to 2.9 in *pre-harvest* period and declined further to 2.7 in *harvest* and 1995 *post-harvest* periods.

The mean number of meals consumed varied significantly by gender of household head in *post-harvest* period Nov-94 (p=0.002) and *pre-harvest* period Mar-95 (p=0.037). During these two survey periods and also consistently throughout the year *de facto* female headed households on average ate slightly more meals per day than male and *de jure* female headed households. In contrast, *de jure* female headed households consistently consumed on average less number of meals per day compared with the other two groups.

The mean number of meals consumed per day also varied significantly by household SES. As expected on average the lower income group, the 'very poor' consistently ate less meals per day than the two higher income groups throughout the year. The differences were significant in all seasons with the exception of the *harvest* period

[2] Longitudinal sample includes all households which answered all four rounds of 24-hr recall

when all income groups ate on average similar numbers of meals per day. The disparity in the number of meals consumed between the three income groups was most apparent during the *pre-harvest* period. The *pre-harvest* season in Buhera is a time when food is generally short. This was further exacerbated in 1995 by the occurrence of the drought. From these results it seems that the lower income tercile had to decrease their meals substantially during this period and faired worst in the drought (Table 4.5.2a&b).

The mean number of meals consumed per day varied significantly between agro-ecological zones; the observed pattern was inconsistent throughout the year and was largely not associated with agricultural potential. During the 1994 *post-harvest* the Hochberg's GT2 *a posteriori* test indicated that the driest zone V consumed significantly fewer meals per day than zones III and IV ($p<0.001$). In contrast, in the *harvest* season, the Hochberg's GT2 *a posteriori* test indicated that households located in zone IV consumed on average more than the households located in higher potential area zone III and the driest region zone V ($p=0.014$). During the 95 *pre-harvest* and *post-harvest* periods, the differences in the mean number of meals consumed by agro-ecological zone were statistically insignificant.

The longitudinal analyses suggested that the seasonal variation in the mean number of meals consumed per day varied between different types of households. Figures 4.3-4.5 illustrate the interaction between the mean number of meals consumed per day and gender of household head, household SES and agro-ecological zone, respectively. There was no significant difference in the seasonal variation in the mean number of meals consumed by gender of the household. It is evident from Figure 4.3 that male and *de facto* and *de jure* female headed households virtually paralleled each other throughout the agricultural year. In contrast, there was a significant difference between household SES and the seasonal change in the meal number of meals consumed between the *harvest* and *post-harvest* period ($F=3.744$, $p=0.025$) (statistics not tabulated), see Figure 4.4. The mean number of meals consumed by the 'very poor' continued to decline, whereas for the 'poor' the mean of meals consumed increased and for the 'non-poor' the mean number remained static. There was also a significant interaction observed between agro-ecological zone and seasonal variation in the mean number of meals consumed on two occasions within the year. Between the 1994 *post-harvest* season and 1995 *pre-harvest* season the mean number of meals consumed by households located in region III and IV declined whereas in region V they increased although the difference was statistically insignificant. Also, between the *harvest* and *post-harvest* period there was a highly significant variation with the mean number of meals continuing to decline for households located in zone IV whereas they increased in zones III and V (F=5.422; p=0.005), (statistics not tabulated), see Figure 4.5. There was no significant difference in the mean number of meals and growing drought tolerant crops (statistics not tabulated).

4.5.3 Dietary quality: was assessed using a Food Variety Score (FVS) and a Dietary Diversity Score (DDS); the definitions for these two indices are outlined in Chapter 3. Both, indices were computed for all four survey rounds of 24-hr recall and FFQ. Spearman rank correlation was used to examine the association between the 24-hr recall responses that represented one day's meals and the FFQ answers that represented the previous 4-months consumption. The results generated suggested that there was a highly significant positive correlation between the total number of foods consumed per day and those recalled for the previous 4-months in each survey round (*post-harvest*: r=0.478, $p<0.01$; *pre-harvest* r=0.326; $p<0.01$; *harvest*: r=0.420; $p<0.01$; *post-harvest* r=0.445; $p<0.01$) (statistics not tabulated). These results suggest that households stating that they consumed a large number of different foods over the previous 4-month period also ate a varied diet the previous day prior to answering both sets of questionnaires.

Surprisingly, during the study 162 different foods were listed in the FFQ. Of these 149 were consumed during the 1994 *post-harvest* period (Jul-94 to Oct-94), 130 during the *pre-harvest* season (Nov-94 to Feb-95); 138 during the *harvest* period (Mar-95 to Jun- 95), and 110 during the *post-harvest* period (Jul-95 to Oct-95). Over a third (38.0%) of the foods listed were wild: 30 (18.4%) wild fruits, 16 (9.8%) wild green leafy vegetables; 16 (9.8%) wild animals, birds or insects. The number of different foods consumed varied by season within and between households.

The basic diet in Buhera district is a thick stiff porridge called Sadza made from the staple cereal crops (maize, millet or sorghum). This is served with a relish predominantly made from green leafy vegetables that may be supplemented with meat, fish or sour milk. This diet was consumed by virtually all households as is clearly illustrated by the bar charts that show the proportion of households consuming each food group in 24hr-recall and FFQ by season (Figures 4.6-4.7). After cereals and green leafy vegetables, sugars and fats/oils were the next commonly consumed food groups. Often these two groups are omitted from DDS. However, it was evident from the analyses that the frequency of consumption of these two food groups along with cereals probably provided the main source of dietary energy for the majority of households. Hence, it was deemed appropriate to include both fats/oils and sugars within the food grouping system as it provided an invaluable insight into the overall quality of the diet.

Meat consumption was lowest in the *harvest* period and highest in the *post-harvest* period for both the 24 hr recall and FFQ. The proportion of households consuming meat and fish in the 24 hr recall ranged between 17.3-28.6% and in the FFQ ranged between 88.1-95.0%. The relatively high proportion of households reporting meat or fish in each round of FFQ suggests that this food group was consumed by the majority of households during each 4-month recall period. However, caution should be interpreted in these results as it does not take into account the frequency the meat was consumed. The use of dairy products was cited proportionally by more households during the 24 hr recall relative to meat/fish consumption; the reverse pattern was observed in the FFQ. Within the dairy category, sour milk (lacto) was one of the most frequently used product served as an accompaniment to Sadza.

An analysis was carried out to examine the association between cattle, goat and chicken ownership and beef, goat, milk, chicken and egg consumption. As expected, there was a significant positive association between livestock ownership and consumption of animal products. Households owning cattle and goats were twice as likely to eat meat and drink milk. Households owning poultry were three times more likely to eat eggs (statistics not tabulated).

The proportion of households consuming fruits in the 24 hr recall was highly variable throughout the year ranging between 1-29%. Whereas the seasonal fluctuations in the FFQ responses were less marked, ranging between 78.2-98.0% throughout the year. Interestingly, when the proportion of households consuming fruit increased the proportion of households consuming sugar decreased. This pattern was replicated in both the 24 hr recall and FFQ and maybe indicative of substitution.

The discrepancies between the proportion of the households consuming each food group on a daily basis and the proportion consuming each food group over a 4-month period illustrates the limitation of using 24 hr recall to assess dietary quality. One day's intake can have minimal resemblance to the habitual diet. For example, the consumption of fruits (8.6%), insects (3.0%) and tubers (0.9%) was extremely low in the 24 hr recall taken during the *post-harvest* period (Nov-94). However, the FFQ, which was administered concurrently, suggested that the consumption of fruits, insects and tubers for the previous 4-months was relatively much higher, 98.0%, 30.6% and 87.2%, respectively.

To provide an insight into the overall quality of the diet of the sampled households the number of households stating that they consumed each food group were summed and subsequently expressed as proportion of the total number of responses. This analysis was repeated seasonally and illustrated by a series of pie charts (Figure Nos. 4.8-4.11). The seasonal variation in consumption of fruits, tubers, other vegetables and insects becomes evident. It is also apparent that the majority of households consume cereals, green vegetables, fats and sugars consistently throughout the year. This was verified by ranking the top ten most frequently cited foods in the 24 hr recall and FFQ's by season (Tables 4.5.8-4.5.9). Maize meal ranked first in both questionnaires in all three seasons. Cooking oil and sugar were ranked either second or third throughout the year. Green leafy vegetables in various forms, specified or non-specified were also ranked highly consistently throughout the year. In the *pre-harvest* 'rainy season' water melon and mangoes featured within the ten most popular foods.

4.6 Environmental characteristics of the household sample

Three characteristics were used to assess the households environmental condition these were type of dwelling, access to sanitation and potable water.

4.6.1 Type of dwelling: Housing type was divided into three categories: traditional, mixed and modern. The construction materials used to build a dwelling are often used as a proxy for socio-economic status. In this study, a modern construction was considered superior and the traditional unit of poorer quality. Two thirds (66.5%) of the sample used traditional materials, nearly a quarter (24.1%) used mixed fabrication and 9.5% used a modern structure. The distribution of the three types of household construction varied significantly by gender of household head (p=0.002). *De facto* female headed households were significantly more likely to reside in units made of mixed materials compared to male headed households, the majority (74.5%) of whom resided in traditional units. The relatively higher usage of purchased materials observed amongst *de facto* female headed households maybe reflect investment of higher incomes through remittances. The relationship between household SES and type of household was also highly significant. As expected the 'non-poor' and higher income tercile were significantly more likely to reside in a modern structure whereas a higher proportion of the 'very poor' and lower income tercile resided in a traditional dwelling (Table 4.6.2a&b). The association between agro-ecological zone and dwelling structure was statistically insignificant (Table 4.6.3).

4.6.2 Household access to sanitation: Less than a third of the households sampled had access to an acceptable toilet system i.e. Blair or pit latrine. Two-thirds (67.6%) of the households sampled had no access to sanitation, a fifth (21.5%) used a Blair toilet and 10.9% used a pit latrine. The variation in the access to sanitation and gender of household head was minimal and statistically insignificant (Table 4.6.1). In comparison, there was a significant association between agro-ecological zone and access to sanitation although the pattern was not linear (p=0.008). Two thirds of the households located in zones III and V had no access to sanitation compared to three-quarters residing in Zone IV. Zone III had increased access to latrines compared to zone IV, which had relatively higher access to Blair toilets (Table 4.6.3). Although, a distinct inverse linear trend between income terciles and no access to sanitation was observed, the relationship between SES and sanitation was statistically insignificant (Table 4.6.2a&b).

4.6.3 Household access to water: The provision of potable water for domestic purposes is a key priority in maintaining and improving household welfare. Just over a third (39.4%) of the households used protected (pipe, well or bore-hole) water sources, 41.2% used unprotected (well, rain water, river) and nearly a fifth (19.4%) used a mixture of both protected and unprotected in *pre-harvest* rainy season. The lack of rain and its poor distribution had a negative impact on access to potable water during the *harvest* period; the proportion of households using protected water decreased 7.1% and nearly a third (32.3%) had to use water from both protected and unprotected sources. With the onset of rains during the latter half of the *post-harvest* period the number of households using protected water sources increased to the level observed in the *pre-harvest* period.

The association between gender of household head and access to protected water sources was statistically insignificant throughout the year. Generally, female headed households were more likely to use protected water sources during each season compared with male headed households. The access to potable water did not vary significantly by household SES throughout the year, irrespective of the household income classification used (Table 4.6.2a&b). In contrast, there was a highly significant association between agro-ecological zone and access to potable water in each season (p<0.001). The generally wetter and more developed agro-ecological zone III had 2.7 times (95% CI:1.6-4.5) more access to potable water compared with the drier zones

IV and V (p<0.001) during the *pre-harvest* period and 1.6 times (95% CI: 0.9-2.6) and 1.9 times (95% CI: 1.1-3.2) more access during *harvest* and *post-harvest* periods (statistics not tabulated).

4.6.4 Household access to fuel for cooking and lighting: Only two different sources of fuel were used for cooking, firewood collected from the surrounding environment and paraffin, which was purchased. The most common source of cooking fuel was firewood, which was used by the majority (98.0%) of the households; the remaining 2% used paraffin. Five different sources of fuel were used for lighting. The majority (71.6%) of households used a home-made paraffin lamp for lighting, 13.8% bought candles, 8.0% used a commercial lamp and 6.3% used firewood; one household had access to solar electricity. The distinct lack of variation in cooking fuel meant that there was no association between fuel and gender of household head. There was evidence that more households in zone III used paraffin for cooking whereas all households in zone V used only wood, although the difference was statistically insignificant. There was a significant association between the source of lighting and agro-ecological zone. Households located in zone III were significantly more likely to use more expensive sources, candles and commercial paraffin lamps compared to zone IV and V (statistics not tabulated).

4.7 Location characteristics of household sample

The household sample was analysed by its location, including agro-ecological zone, remoteness and distance to services such as hospitals and markets.

4.7.1 Agro-ecological zone: No association was observed between agro-ecological zone and gender of household head (Table 4.3.3). However, there was a significant association between household SES and agro-ecological zone, the very poor or lower income tercile was more likely to be located in drier region V (see section 4.3.2).

4.7.2 Remoteness: As expected the proportion of households classified as remote by the enumerators increased, as the agro-ecological zone got drier. In contrast, slightly more *de jure* female headed households resided in remote areas compared to either male or *de facto* female headed households possibly contributing further to their level of vulnerability. The majority of 'non-poor' were classified as less-remote however when the household sample was divided into income terciles no relationship was observed between household SES and remoteness (Table 4.6.1-3).

4.7.3 Distance to health services and nearest market: There was a high degree of concordance between the enumerators categorisation of remoteness and the GPS estimated distances to services. Remote households had significantly further to travel to markets (t=6.814, p<0.001). Physical access (distance) to formal health services including district hospital, rural hospital and clinic were longer for remote households; the variation was significantly different for clinics (t=3.878, p<0.001). In contrast, the distance for remote and less remote households to outreach posts were similar. There was limited variability in the distances travelled by male and female headed households to formal health services. In contrast, a significant difference in the distances to rural hospitals, outreach posts and markets was observed between agro-ecological zones. Households in zone IV were significantly further from a rural hospital and closer to an outreach post compared to households located in zone III. Whereas households in zone V were the furthest from markets (Table 4.7.3).

4.8 Defining the study population: Who is a household resident?

The demographic profile of a household population is important from a number of perspectives, including estimation of sample bias and establishment of key demographic characteristics that are important mediating factors in the acquisition of nutrition. Members of the selected households were initially divided into two broad categories *de facto* and *de jure*. The *de facto* population is one that is present at the time of enumeration, whereas the *de jure* population refers to individuals who are normally considered a household resident but who were not physically resident at the time of the enumeration. The decision who to enumerate, the *de facto* and or *de jure* household population was largely determined by the nature and design of the study, its objectives and resources (WHO, 1985).

The Buhera study was primarily concerned with the food security, health and nutritional status of the Buhera population. In theory, this narrowed the target population to those individuals physically resident in the selected household at the time of enumeration, that is, the *de facto* population. However, in practice the nature and design of the study introduced additional dimensions. These had an impact on who was ultimately enumerated. The prospective longitudinal survey design and the dynamic heterogeneous nature of the survey population particularly complicated the definition of household resident.

The Buhera study used a longitudinal prospective panel survey design. This introduced a time dimension with more than one enumeration period. With this type of study design the *de facto* and *de jure* population can vary overtime. The main causes of sample variation in the Buhera study were death, newborns, out and inward migration and refusal to co-operate. Each of these factors had a direct impact on the categorisation of individuals into the two distinct *de facto* and *de jure* population groups.

Literally applying the term *de facto* to the Buhera study meant that all individuals who were physically resident at the outset of the study were enumerated and included as a *'de facto'* household member. However, the inclusion of more than one observation period meant that the resident status of some of the *de facto* household members changed to being a *de jure* household member in a subsequent enumeration period.

In the Buhera study the *de facto* population included 'all persons living in the selected households at the start of the study in Oct-94 and all those persons who subsequently came to live in the selected household after the start of the study'. The *de facto* population was dynamic, including members who died or those that were born during the study and those migrating. Initially an individual was categorised as a *de facto* household member if they were *physically resident* during at least one enumeration period. Retrospectively this classification changed to reflect the amount of time the individual was resident within the household and the reliability of the attributed information. The reasons for being or becoming a *de jure* household member varied. Although, somewhat arbitrary it was decided to examine the length of time that an individual was physically resident within the selected household. This would be used to distinguish if the individual was a *de facto* or *de jure* household member, as it would more closely reflect the *per capita* usage of the available resources.

4.8.1 Dynamic heterogeneous nature of the Buhera survey population and its impact on the definition of resident: The sample population in the Buhera study was very dynamic; transient household members were a common sub-group within the Buhera sample. The main source of attrition in the Buhera study was outward migration. Migration is a universal coping strategy implemented by smallholder agricultural households to diversify income sources and alleviate household risk of food insecurity. It was common for male adult household members to migrate to urban centres to find off-farm employment and for other household members particularly young children to regularly move in an out of the household subsequently decreasing *per capita* household consumption.

From the outset of the study the importance of off-farm income and remittances were known to play a significant role in determining the level of household food security. To capture this dimension of household income, the target population was broadened to include *de jure* household members who were sending back remittances to the selected households. The heterogeneous nature of these household remitters further complicated the categorisation of residents. Some of the remitters were never physically resident in the household and as such were enumerated as a *de jure* household member while others were transient; constantly moving in and out of the household. The transient nature of the Buhera sample meant that to a certain extent both the *de facto* and the *'de jure'* population had an opportunity to be included in the study. Only household members who were never 'physically resident' that is, they were not observed throughout the year long study were assumed to be *'de jure'* household members.

The transient population introduced an intangible aspect to the concept of resident. To a certain extent any cut-off point used to define an individual as either a resident or non-resident is arbitrary. Unravelling and ultimately deciding, "Who is a resident?" was a complex problem. The approaches used in this thesis to verify resident status are founded on the type and frequency of observation associated with each individual. These were subsequently used as the main criterion for *de facto* and *de jure* membership.

4.8.2 Description of the de facto and de jure population: Retrospective analysis was used to classify overall each individual listed as either a *de facto* and *de jure* household member. To reflect the movement between one category and the other, various sub-categories within the *de facto* and *de jure* population were also devised. Appendix 2 -Table 4.8.1 summarises the number and percentage of listed individuals classified as *de facto* or *de jure* household members overall and by sub-category. Altogether, the results suggest that two-thirds of the individuals listed could be classified as *de facto* household members. Conversely, this meant that 40% of the individuals listed were *de jure* household members. The main reasons for the relatively high ratio of *de jure* to *de facto* population is attributed to the large number of affiliated household members such as those who sent back remittances but who physically resided elsewhere or visitors who were resident for only one survey period or household members who were listed but were not observed throughout the study.

4.8.3 Comparison of the demographic profile of the de facto and de jure household population: The demographic profile of the *de facto* and *de jure* population was ascertained to identify major gender or age differences between the two populations. These are summarised in Appendix 2-Tables 4.8.5-4.8.8. Over half (55.7%) the *de facto* population were female whereas more than half (56.2%) the *de jure* population were male. The gender differences were more stark within the middle-aged category, two-thirds of the *de facto* population were female but over 80% of the *de jure* population aged between 35-45 years were male. The female gender bias observed amongst the *de facto* population and male bias observed amongst the *de jure* population was highly significant (p<0.001).

Likewise, there was a highly significant age difference observed between the *de facto* and *de jure* population. A larger proportion of children <14 years and adults aged ≥40 years, and fewer 15-39 years olds were observed amongst the *de facto* population (p<0.001). The *de facto* population also had a significantly lower median age (12.9 years) than the *de jure* population (15.4 years).

4.8.4 Estimation of the dependency ratio of de facto sample population: Children <15 years of age accounted for over half (56.8%) the *de facto* population, whereas the elderly constituted 3.7%. The dependency ratio of *de facto* population was 1.53; this means that there are roughly 1.5 dependants for every potential adult carer. The high dependency ratio of *de facto* population is considered a contributing factor to the vulnerable nature of the demographic composition of the resident rural population.

4.8.5 Description of the sub-categorisation of de facto household members: The 2,174 *de facto* household members were divided into four sub-categories: full-time members who were observed on 3-4 occasions, transient residents who regularly moved in and out of the household and were observed on at least two occasions, newborns and individuals who died during the study. Full-time residents who were enumerated for three or four occasions accounted for the majority (55.0%) of the listed household members. Transient household members who regularly migrated in and out of the household accounted for an additional 4.5% of the sample. Throughout the year long study 80 births and 40 deaths were reported.

4.8.6 Description of the sub-categorisation of de jure household members: The 1,289 *de jure* household members were divided into nine sub-categorises. The first category pertained to remitters, who contributed income or goods in-kind, a second category where members listed but were non-resident throughout the study and were not remitting. The third category was children attending boarding school. The retrospective analyses subsequently identified three categories of visitors. Visitors were defined as *de jure* household members who were enumerated once during the study. The fourth, fifth and sixth categories of *de jure* population each related to visitors; visitors who had also sent back remittances, visitors who had not remitted and children from boarding school who visited the household once. The seventh category of *de jure* members pertained to members of the selected households that dropped out of the study. The eighth and ninth category referred to duplicate entries or errors.

Over a quarter of the *de jure* population, 282 (21.9%) were sending back remittances to the household. This approximated to 8.1% of the total number of household members listed. Interestingly, 289 (8.3%) individuals listed had no evidence that they contacted the household throughout the study period. These individuals had no anthropometric measure, did not respond to any individual level question, they had no valid reason for not participating and were not remitters. It was assumed that these individuals were living elsewhere. They were subsequently categorised as non-resident non-remitters. Over a quarter of the *de facto* household population, 8.5% of the total sample was identified to be erroneous. The 291 duplicates and 5 errors were subsequently excluded from further analysis.

4.8.7 Comparison of the age and gender composition of the sample population by de facto and de jure sub-categories: The demographic profile of each sub-category of the *de facto* and *de jure* population was ascertained to identify any major gender or age differences between each group an important consideration when establishing sample bias. Appendix 2-Tables 4.8.3-4.8.8 provide a summary of the age and gender distribution of the sample within the various sub-categories of the *de facto* and *de jure* population. The main demographic features of the full-time *de facto* household members have been outlined above. The majority of transient *de facto* population regularly migrating in and out of selected households were female adults visiting their spouse or other relatives during the winter period although the association between gender and age was not significant. As expected, there was a highly significant association between gender and age within the remitting *de jure* population; more males remitting within all age groups. There was no association between age and gender amongst non-residents not remitting. Interestingly, there was a strong association between age and duplication. A third of the duplicates were pre-schooler's and a fifth were middle aged, the majority of whom were male. The relatively higher prevalence of duplication within these two age cohorts can be explained by the common use of more than one name (Shona and English) amongst young children and the frequent double counting of male household heads in polygamous relationships.

4.8.8 Age pyramid of the total household population, the de jure and de facto population in November 1995: The age-sex structure of total household population and the *de jure* and *de facto* population are illustrated by use of a population pyramid depicted in Figures 4.12-4.14. The wide-based age pyramid of the total household sample depicts the relatively larger proportion of younger age groups compared to middle-aged and elderly. This shaped pyramid is typical of a less developed country with a high fertility rate and a relatively lower life expectancy. The number of children under 5 years is less than the number of children aged between 5-9.99 years and 10-14.99 years a finding that is consistent with a recent fertility decline observed in Zimbabwe (CSO, 1995). The relatively broader base and right-skewness of the *de facto* compared to the *de jure* population pyramid Figures 4.13 and 4.14 clearly illustrates the youthfulness and female bias of the resident rural population, its main demographic features. The 'missing' adult males of the *de facto* population are observed in the *de jure* population pyramid as male remitters. Over half the female *de jure* population were aged between 20-29 years; these women were either living with spouses in urban centres, or in the process of setting up new homes or working as domestics in the city. A fifth of the *de jure* population were aged under 15 years, these children either attended boarding school or lived with relatives elsewhere.

4.8.9 Sample population crude birth and death rates: There were a total of 73 live births and 40 deaths reported during the 12-month study. These values were used to estimate the annual crude birth rate (CBR) and crude death rate (CDR) and compared to the CBR and CDR estimated for Buhera district in the 1992 Census. The 45 deaths occurring during the 12-month study was equivalent to a crude death rate (CDR) of 14.2 deaths per 1,000 population. This value was 1.6% higher than the CDR estimated for Buhera District during the 1992 Census. In contrast, the estimated CBR for the study of 25.5 births per 1,000 population was 8.6% lower than the 1992 Census estimate for Buhera (CSO, 1995). It is not known if the difference is attributed to either under-reporting of births or neonatal deaths or an indication of a significant decline in births. A third of all the deaths reported occurred amongst pre-schooler's; three-quarters of the adults who died were male. Whereas there was a slight female bias in the number of children born, the gender difference was statistically insignificant.

4.9 Summary

1. Household attrition was relatively low (5.6%). Of the twenty households who dropped out, thirteen were due to outward migration, six had a death within the household, one refused to participate after being enrolled more than three months on the study. The latter group were not replaced.
2. A total of 349 households had baseline demographic data, of these just over half the sample households were male headed, 45.0% were female headed. Of the female headed households the majority 68.2% were *de facto* female headed, 31.8% were *de jure* female headed. Significantly, different demographic, socio-economic and environmental conditions were observed by gender of the household head. Male headed households were significantly larger than both *de facto* and *de jure* female headed households. *De facto* female headed households had a tendency to be slightly wealthier; the mean annual household income *per capita* was approximately a third more than their counterparts. This was positively reflected in the type of housing, value of livestock holdings and number of agricultural and household assets. In contrast, *de jure* female headed households were characteristically more vulnerable: they were significantly older, had lower levels of income, agricultural production, livestock holding, assets and years of education. These results suggests within the group of female headed households there are

contrasting differences; *de jure* female headed households are significantly more vulnerable nutritionally.

3. A total of 343 households had sufficient data over-time to provide a reasonable estimate of annual *per capita* income which was subsequently used for SES categorisation. The mean and median levels of income of the sampled households suggest a high level of poverty existed amongst the sampled households. A head count index of 0.95 suggests that 95% of the households sampled were categorised as 'poor' the majority (87.8%) of which were classified as 'very poor' or 'food insecure'.
4. Significant associations were observed between agro-ecological zones and access to markets, formal health-care, potable water and sanitation. The results support previous documentation that the drier lower agricultural potential agro-ecological zones IV and V are significantly less developed than the higher potential zone III. The drier zones have significantly less access to markets, formal health-care, potable water and sanitation. Combined with larger sized households with higher dependency ratios due to high levels of absent migratory adult males this increased the drier zones level of nutritional vulnerability.
5. The prevailing environmental characteristics of the households sampled were poor. Approximately 40% used unprotected water sources throughout the year, one in three households had access to potable water, approximately a fifth to third used a combination of both protected and unprotected. Access to potable water varied during the year. There was increased access to protected water during the *pre-harvest* and *post-harvest* periods and least access during dry winter *harvest* period. The overall lack of rains and its poor distribution had a negative impact on access to potable water during the dry season. Access to sanitation was also poor, over two-thirds of the sampled households had no toilet facility. The relatively low proportion of houses using pit latrines and Blair toilets was seemingly attributed to financial constraints since households with higher SES had improved access to sanitation.
6. The level of education was assessed to be relatively high compared to other rural Africa communities with 89.8% of the household heads having had some

education. The number of years of education received was inversely correlated with age suggesting that access to education has gradually improved with time.

7. A total of 3463 individuals were listed in the Buhera household sample of which two-thirds were enumerated at least once during the study. The remaining 40% were affiliated to the sampled households but not observed. Just over a sixth of the *de jure* population were income (cash or in-kind) remitters. Approximately 8.4% were duplications.
8. The age and gender composition of the *de facto* and *de jure* population differed significantly. There was highly significant female bias observed amongst *the de facto* population and a highly significant male bias observed amongst remitters.
9. The wide-based age pyramid of the sample population depicts a relatively larger proportion of younger age groups compared to middle-aged and elderly. The slightly lower number of children aged between 5-9.99 years and 10-14.99 years is consistent with a recent fertility decline observed in Zimbabwe.
10. There were approximately twice as many births as there were deaths during the year long study. The annual crude birth and death rates were estimated to be 25.5 per 1,000 and 14.2 per 1,000 population, respectively. A third of the deaths occurred amongst pre-schooler's and there was highly significant male bias amongst adult deaths.

Chapter 4 - Tables

Tables for section 4.3 Demographic characteristics by household type

Association between gender of household head and household socio-economic status SES											
Socio-economic status (SES)	**Total sample** n=343		**Male** n=192		***De facto* female** n=107		***De jure* female** n=50		**Chi-square statistic**		
PASS Classification	n	%	n	%	n	%	n	%	df	χ^2	*p*
Very poor	301	87.8	174	91.1	85	81.0	42	89.4			
Poor	25	7.3	9	4.7	12	11.4	4	8.5	4	7.604	n.s.
Non-poor	17	5.0	8	4.2	8	7.6	1	2.1			
SES											
Tercile I	114	33.2	74	38.7	20	19.0	20	42.6			
Tercile II	115	33.5	68	35.6	31	29.5	16	34.0	4	25.208	<0.001
Tercile III	114	33.2	49	25.7	54	51.4	11	23.4			

Table 4.3.1 *Association between gender of household head and household socio-economic status (SES)*

Association between agro-ecological zone and household socio-economic status SES											
Socio-economic status (SES)	**Total sample** n=343		**Zone III** n=106		**Zone IV** n=138		**Zone V** n=99		**Chi-square statistic**		
PASS Classification	n	%	n	%	n	%	n	%	df	χ^2	*p*
Very poor	301	87.8	83	78.3	122	88.4	96	97.0			
Poor	25	7.3	13	12.3	9	6.5	3	3.0	4	17.417	0.002
Non-poor	17	5.0	10	9.4	7	5.1	0	0.0			
SES											
Tercile I	114	33.2	25	23.6	36	26.1	53	53.5			
Tercile II	115	33.5	34	32.1	55	39.9	26	26.3	4	29.660	<0.001
Tercile III	114	33.2	47	44.3	47	34.1	20	20.2			

Table 4.3.2 *Association between household socio-economic status (SES) and agro-ecological zone*

Association between gender of household head and agro-ecological zone											
Agro-ecological Zones	**Total sample** **n=349**		**Male** **n=192**		***De facto* female** **n=107**		***De jure* female** **n=50**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	*p*
III	106	30.4	58	30.2	28	26.2	20	40.0			
IV	142	40.7	75	39.1	49	45.8	18	36.0	4	3.895	n.s.
V	101	28.9	59	30.7	30	28.0	12	24.0			

Table 4.3.3 *Association between gender of household head and agro-ecological zone*

Demographic characteristics by gender of household head											
Demographic characteristics	**Total Sample n=349**		**Male n=192**		***De facto* female n=107**		***De jure* female n=50**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Household size	5.7	3.0	6.7	3.2	4.6	2.0	4.2	2.3	2	27.901	<0.001
Number of adult males	0.8	0.7	1.2	0.5	0.2	0.4	0.3	0.6	2	189.059	<0.001
Number of adult females	1.3	0.7	1.4	0.9	1.2	0.4	1.3	0.7	2	4.711	0.010
Number of children <15 yr.	3.2	2.1	3.7	2.3	2.9	1.5	2.4	1.8	2	9.747	<0.001
Dependency ratio	2.0	1.2	1.9	1.2	2.1	1.2	2.1	1.2	2	1.867	n.s.
Age (yr.) HH head	45.5	16.5	47.8	16.3	35.1	10.9	58.8	14.2	2	50.586	<0.001
No. (yr.) Education HH head	5.4	3.1	5.6	3.1	6.3	3.0	2.8	2.4	2	24.718	<0.001
No. (yr.) Education HH head*	4.9	3.9	5.8	2.6	4.8	3.5	4.0	3.5	2	1.762	n.s.

Demographic characteristics by gender of household head							
Demographic characteristics	**Total Sample n=349**	**Male n=192**	***De facto* female n=107**	***De jure* female n=50**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
Household size	5.3	6.5	4.3	3.9	2	58.379	<0.001
Dependency ratio	1.8	1.5	2.0	2.0	2	5.400	n.s.
Age (yr.) HH head	42.6	44.9	33.9	60.4	2	79.256	<0.001
No. (yr.) Education HH head	5.0	6.0	7.0	2.5	2	43.862	<0.001

Association between gender of household head and level of education											
Education level	**Total sample**		**Male**		***De facto* female**		***De jure* female**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	*p*
No education	41	11.9	17	9.0	10	9.4	14	28.0			
Primary school	225	65.4	126	67.0	64	60.4	35	70.0	4	25.546	<0.001
More than primary school	78	22.7	45	23.9	32	30.2	1	2.0			

Table 4.3.4 *Association between gender of household head and demographic characteristics (*ANCOVA- Analysis of covariance)*

Demographic characteristics by household socio-economic status (SES)											
Demographic characteristics	Total Sample n=343		Very poor n=301		Poor n=25		Non-poor n=17		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	p
Household size	5.7	3.0	5.9	3.0	4.7	2.5	3.5	1.2	2	6.978	0.001
Number of adult males	0.8	0.7	0.9	0.7	0.8	0.9	0.6	0.7	2	0.809	n.s.
Number of adult females	1.3	0.7	1.4	0.7	1.3	0.4	1.3	0.9	2	0.296	n.s.
Number of children <15 yrs.	3.3	2.1	3.4	2.1	2.3	1.6	1.5	1.0	2	9.815	<0.001
Dependency ratio	2.0	1.2	2.0	1.2	1.3	0.8	1.5	1.0	2	6.140	<0.001
Age (yr.) HH head	45.4	16.5	45.2	16.7	48.1	16.0	46.3	15.2	2	0.394	n.s.
No. (yr.) Education HH head	5.5	3.1	5.3	3.1	5.2	2.8	7.8	3.1	2	5.297	0.005
No. (yr.) Education HH head*	6.3	2.5	5.3	2.5	5.6	2.5	7.9	2.5	2	1.605	n.s.

Demographic characteristics by household socio-economic status (SES)							
Demographic characteristics	Total Sample n=343	Very poor n=301	Poor n=25	Non-poor n=17	Kruskal-Wallis		
	Median	Median	Median	Median	df	H	p
Household size	5.3	5.8	5.0	3.3	2	18.508	<0.001
Dependency ratio	1.8	1.9	1.1	1.5	2	12.944	0.002
Age (yr.) HH head	42.5	42.1	44.8	45.0	2	1.226	n.s.
No. (yr.) Education HH head	6.0	5.5	5.0	8.0	2	8.473	0.014

Association between gender of household head and level of education of household head											
Education level	Total sample n=338		Very poor n=296		Poor n=25		Non-poor n=17		Chi-square statistic		
	n	%	n	%	n	%	n	%	df	χ^2	p
No education	37	10.9	36	12.2	1	4.0	0	0.0			
Primary school	223	66.0	197	66.6	18	72.0	8	41.0	4	11.429	0.022
More than primary school	78	23.1	63	21.3	6	24.0	9	52.9			

Table 4.3.5a *Association between household socio-economic status (SES) and demographic characteristics (*ANCOVA- Analysis of covariance)*

Demographic characteristics by household socio-economic status (SES)											
Demographic characteristics	**Total Sample n=343**		**Tercile I n=114**		**Tercile II n=115**		**Tercile III n=114**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Household size	5.7	3.0	6.8	2.9	5.7	3.1	4.6	2.6	2	16.428	<0.001
Number of adult males	0.8	0.7	0.8	0.6	0.8	0.7	0.7	0.7	2	2.508	n.s.
Number of adult females	1.3	0.8	1.3	0.7	1.8	0.8	1.3	0.7	2	0.195	n.s.
Number of children <15 yrs.	3.3	2.1	4.2	2.1	3.1	2.0	2.4	1.7	2	24.957	<0.001
Dependency ratio	2.0	1.2	2.3	1.1	2.0	1.2	1.6	1.1	2	8.126	<0.001
Age (yr.) HH head	45.4	16.5	44.0	14.9	47.9	18.0	44.3	16.3	2	2.041	n.s.
No. (yr.) Education HH head	5.5	3.1	4.9	3.2	5.5	2.9	6.0	3.1	2	3.938	0.020
No. (yr.) Education HH head*	5.5	2.5	4.7	2.5	5.7	2.6	5.9	2.5	2	1.392	n.s.
Demographic characteristics by household socio-economic status (SES)											
Demographic characteristics	**Total Sample n=343**		**Tercile I n=114**		**Tercile II n=115**		**Tercile III n=114**		**Kruskal-Wallis**		
	Median		Median		Median		Median		df	H	*p*
Household size	5.3		6.8		5.0		4.0		2	44.336	<0.001
Dependency ratio	2.0		2.0		1.5		1.5		2	20.635	<0.001
Age (yr.) HH head	42.5		40.4		44.9		42.5		2	2.615	n.s.
No. (yr.) Education HH head	6.0		5.0		6.0		6.0		2	5.810	n.s.
Association between household SES and level of education of household head											
Education level	**Total Sample n=338**		**Tercile I n=113**		**Tercile II n=112**		**Tercile III n=113**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	*p*
No education	37	100.9	20	17.7	10	8.9	7	6.2			
Primary school	223	66.0	70	61.9	81	72.3	72	63.7	4	12.182	0.016
More than primary school	78	23.1	23	20.4	21	18.8	34	30.1			

***Table 4.3.5b** Association between household socio-economic status (SES) and demographic characteristics (*ANCOVA- Analysis of covariance)*

Demographic characteristics by agro-ecological zone											
Demographic characteristics	**Total Sample n=349**		**Zone III n=106**		**Zone IV n=142**		**Zone V n=101**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Household size	5.7	3.0	5.3	2.3	5.7	3.6	6.0	2.7	2	1.399	n.s.
Number of adult males	0.8	0.7	0.8	0.7	0.7	0.7	0.8	0.7	2	0.470	n.s.
Number of adult females	1.3	0.7	1.4	0.7	1.4	0.8	1.3	0.7	2	0.214	n.s.
Number of children <15 yr.	3.2	2.1	2.8	1.5	3.3	2.4	3.7	2.1	2	4.800	0.009
Dependency ratio	2.0	1.2	1.8	1.1	2.0	1.2	2.1	1.3	2	2.518	n.s.
Age (yr.) HH head	45.5	16.5	49.0	15.8	43.7	16.8	44.4	16.2	2	3.477	0.032
No. (yr.) Education HH head	5.4	3.1	5.7	3.0	5.9	2.8	4.4	3.5	2	7.145	0.001
No. (yr.) Education HH head*	5.4	2.6	6.2	2.5	5.7	2.5	4.3	2.5	2	4.228	0.015

Demographic characteristics by agro-ecological zone							
Demographic characteristics	**Total Sample n=349**	**Zone III n=106**	**Zone IV n=142**	**Zone V n=101**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
Household size	5.3	5.3	5.0	6.0	2	5.175	n.s.
Dependency ratio	1.8	1.5	1.9	2.0	2	4.757	n.s.
Age (yr.) HH head	42.6	46.1	39.7	42.5	2	7.806	0.020
No. (yr.) Education HH head	5.0	6.0	6.0	5.0	2	10.625	0.005

Association between agro-ecological zone and level of education of household head											
Education level	**Total sample**		**Zone III**		**Zone IV**		**Zone V**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	*p*
No education	41	11.9	7	6.8	7	5.0	27	27.0			
Primary school	225	65.4	72	69.9	100	70.9	53	53.0	4	30.862	<0.001
More than primary school	78	22.7	24	23.3	34	24.1	20	20.0			

Table 4.3.6 *Association between agro-ecological zone and demographic characteristics (*ANCOVA- Analysis of covariance)*

Tables for section 4.4 Socio-economic characteristics by household type

Socio-economic characteristics by gender of household head

Socio-economic characteristics	**Total Sample n=293**		**Male n=170**		***De facto* female n=81**		***De jure* female n=42**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
No. hectares cropped 1993/4	2.3	1.5	2.4	1.8	2.1	1.1	1.7	1.1	2	3.836	0.023
Per capita hectares cropped 93/4	0.44	0.28	0.40	0.28	0.50	0.26	0.48	0.31	2	4.058	0.018
No. hectares cropped 94/5	2.3	1.8	2.6	2.1	1.9	1.1	1.7	1.1	2	6.549	0.002
Per capita hectares cropped 94/5	0.43	0.28	0.40	0.28	0.47	0.26	0.46	0.31	2	2.160	n.s.
Annual income *per capita* (Z$)	700.4	746.0	608.1	715.3	940.3	834.2	539.1	507.4	2	8.332	<0.001
Total value of Livestock (Z$)	6,081.9	7,052.9	6,744.5	7,872.8	5,684.5	5,772.0	4,214.3	5,655.4	2	2.537	n.s.
No. cattle	4.9	5.2	5.6	5.9	4.3	4.1	3.3	4.1	2	4.216	0.016
No. goats	4.8	6.2	4.6	4.8	5.1	4.8	4.7	12.1	2	0.160	n.s.
No. agricultural assets	6.2	3.0	6.5	3.0	6.4	3.1	4.6	2.7	2	8.390	<0.001
No. household assets	3.5	2.6	3.2	2.4	4.3	2.9	2.6	2.1	2	9.591	<0.001

Socio-economic characteristics by gender of household head

Socio-economic characteristics	**Total Sample n=349**	**Male n=192**	***De facto* female n=107**	***De jure* female n=50**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
No. hectares cropped 1993/4	1.82	2.02	2.02	1.62	2	7.239	0.027
Per capita hectares cropped 93/4	0.40	0.31	0.45	0.43	2	13.153	0.001
No. hectares cropped 94/5	1.62	1.82	2.02	1.62	2	8.355	0.015
Per capita hectares cropped 94/5	0.35	0.32	0.41	0.40	2	8.786	0.012
Annual income *per capita* (Z$)	483.1	397.8	696.2	343.5	2	25.182	<0.001
Total value of Livestock (Z$)	4,302.5	4,710.0	4,665.0	1,537.5	2	4.282	n.s.
No. cattle	4.0	4.0	4.0	2.0	2	6.255	0.044
No. goats	4.0	4.0	4.0	2.0	2	7.499	0.024
No. agricultural assets	6.0	6.0	6.0	4.5	2	17.747	<0.001
No. household assets	3.0	2.0	4.0	2.0	2	18.926	<0.001

Table 4.4.1 *Association between gender of household head and socio-economic characteristics*

Socio-economic characteristics by gender of household head											
Socio-economic characteristics	**Total Sample n=349**		**Male n=192**		***De facto* female n=107**		***De jure* female n=50**		**Chi-square statistic**		
No. income sources	n	%	n	%	n	%	n	%	df	χ^2	p
Subsistence only	17	5.0	8	4.2	5	4.8	4	8.5			
1	69	20.1	27	14.1	31	29.5	11	23.4			
2	92	26.8	55	28.8	25	23.8	12	25.5	8	17.338	0.027
3	85	24.8	45	23.6	27	25.7	13	27.7			
≥4	80	23.3	56	29.3	17	16.2	7	14.9			
Remittances received											
Yes	196	57.1	78	40.8	96	91.4	22	46.8	2	73.184	<0.001
No	147	42.9	113	59.2	9	2.6	25	53.2			
Owns plough											
Yes	254	73.4	147	77.4	79	74.5	28	56.0	2	9.357	0.009
No	92	26.6	43	22.6	27	25.5	22	23.9			
Owns draft cattle											
Yes	129	39.3	68	37.0	37	37.0	24	54.5	2	4.931	n.s.
No	199	60.7	116	63.0	63	63.0	20	45.5			
Owns goats											
Yes	262	79.9	145	78.8	87	87.0	30	68.2	2	7.033	0.030
No	66	20.1	39	21.2	13	13.0	14	31.8			
Owns bicycle											
Yes	63	18.3	40	20.9	18	17.1	5	10.2	2	3.139	n.s.
No	281	81.7	151	79.1	87	82.9	44	89.8			
Owns radio											
Yes	93	27.0	46	24.1	41	39.0	6	12.2	2	13.983	<0.001
No	251	73.0	145	75.9	64	61.0	43	87.8			
Owns sewing machine											
Yes	34	9.9	11	5.8	21	20.0	2	4.1	2	17.610	<0.001
No.	311	90.1	180	94.2	84	80.0	47	95.9			

Table 4.4.2 *Association between gender of household head and socio-economic characteristics*

Socio-economic characteristics by household SES											
Socio-economic characteristics	**Total Sample n=293**		**Very poor n=253**		**Poor n=23**		**Non-poor n=17**		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
No. hectares cropped 1993/4	2.3	1.5	2.2	1.5	2.8	2.0	2.5	1.4	2	1.947	n.s.
Per capita hectares cropped 93/4	0.44	0.28	0.41	0.27	0.61	0.26	0.71	0.31	2	14.744	<0.001
No. hectares cropped 94/5	2.3	1.8	2.2	1.9	2.5	1.4	2.7	1.2	2	0.644	n.s.
Per capita hectares cropped 94/5	0.43	0.28	0.40	0.27	0.59	0.26	0.74	0.33	2	16.793	<0.001
Annual income *per capita* (Z$)	700.4	746.0	473.7	289.0	1,719.1	239.3	3,215.2	967.1	2	611.462	<0.001
Total value of Livestock (Z$)	6,081.9	7,052.9	5,121.7	6,091.0	11,304.8	8,775.9	14,555.0	10,241	2	24.964	<0.001
No. cattle	4.9	5.2	4.2	4.6	8.6	6.4	11.1	7.1	2	23.521	<0.001
No. goats	4.8	6.2	4.7	6.2	4.5	3.7	7.3	9.0	2	1.460	n.s.
No. agricultural assets	6.2	3.0	5.9	2.8	8.8	4.1	8.3	2.4	2	15.890	<0.001
No. household assets	3.5	2.6	3.2	2.3	5.8	3.8	5.8	2.7	2	20.534	<0.001

Socio-economic characteristics by household SES							
Socio-economic characteristics	**Total Sample n=343**	**Very poor n=301**	**Poor n=25**	**Non-poor n=17**	Kruskal-Wallis		
	Median	Median	Median	Median	df	H	*p*
No. hectares cropped 1993/4	1.82	1.62	2.02	2.43	2	5.354	n.s.
Per capita hectares cropped 93/4	0.40	0.34	0.61	0.67	2	27.771	<0.001
No. hectares cropped 94/5	1.62	1.62	2.02	2.43	2	7.648	0.022
Per capita hectares cropped 94/5	0.35	0.33	0.51	0.74	2	26.635	<0.001
Annual income *per capita* (Z$)	483.1	393.3	1,740.1	3,076.3	2	110.704	<0.001
Total value of Livestock (Z$)	4,302.5	3,187.5	12,605.0	12,200.0	2	29.215	<0.001
No. cattle	4.0	4.0	9.0	9.0	2	31.569	<0.001
No. goats	4.0	4.0	5.0	7.0	2	3.229	n.s.
No. agricultural assets	6.0	6.0	9.0	9.0	2	24.405	<0.001
No. household assets	3.0	2.0	6.0	6.0	2	24.253	<0.001

Table 4.4.3a *Association between household socio-economic status SES and socio-economic characteristics*

Socio-economic characteristics by household SES											
Socio-economic characteristics	**Total Sample n=293**		**Tercile I n=114**		**Tercile II n=115**		**Tercile III n=114**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
No. hectares cropped 1993/4	2.3	1.5	1.9	1.4	2.4	1.5	2.4	1.7	2	3.376	0.036
Per capita hectares cropped 93/4	0.44	0.28	0.29	0.21	0.46	0.26	0.57	0.31	2	26.521	<0.001
No. hectares cropped 94/5	2.3	1.8	1.9	1.5	2.5	2.1	2.4	1.8	2	2.698	n.s.
Per capita hectares cropped 94/5	0.43	0.28	0.29	0.21	0.44	0.27	0.55	0.30	2	23.810	<0.001
Annual income *per capita* (Z$)	700.4	746.0	206.5	80.2	473.1	99.4	1,423.4	917.5	2	163.624	<0.001
Total value of Livestock (Z$)	6,081.9	7,052.9	3,806.2	5,343.9	5,713.5	6,070.3	9,057.0	8,257.8	2	18.045	<0.001
No. cattle	4.9	5.2	3.0	3.8	4.6	4.7	6.9	6.1	2	16.478	<0.001
No. goats	4.8	6.2	5.0	8.8	4.5	4.1	4.9	5.1	2	0.189	n.s.
No. agricultural assets	6.2	3.0	5.6	2.8	6.1	3.0	7.0	3.2	2	6.106	0.002
No. household assets	3.5	2.6	2.9	2.3	3.2	2.4	4.4	2.8	2	11.519	<0.001

Socio-economic characteristics by household SES							
Socio-economic characteristics	**Total Sample n=343**	**Tercile I n=114**	**Tercile II n=115**	**Tercile III n=114**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
No. hectares cropped 1993/4	1.82	1.62	2.02	2.02	2	11.845	0.003
Per capita hectares cropped 93/4	0.40	0.23	0.40	0.52	2	54.370	<0.001
No. hectares cropped 94/5	1.62	1.62	2.0	2.0	2	7.268	0.026
Per capita hectares cropped 94/5	0.35	0.24	0.40	0.47	2	45.963	<0.001
Annual income *per capita* (Z$)	483.1	218.3	483.1	1088.5	2	304.001	<0.001
Total value of Livestock (Z$)	4,302.5	600.0	3,715.0	7,040.0	2	36.063	<0.001
No. cattle	4.0	2.0	4.0	6.0	2	29.083	<0.001
No. goats	4.0	4.0	4.0	4.0	2	0.966	n.s.
No. agricultural assets	6.0	5.5	6.0	7.0	2	12.063	0.002
No. household assets	3.0	2.0	2.0	4.0	2	24.154	<0.001

Table 4.4.3b *Association between household socio-economic status SES and socio-economic characteristics*

Socio-economic characteristics by household SES											
	Total Sample		Very poor		Poor		Non-poor		Chi-square statistic		
No. income sources	n	%	n	%	n	%	n	%	df	χ^2	p
Subsistence only	17	5.0	17	5.6	0	0.0	0	0.0			
1	69	20.1	65	21.6	3	12.0	1	5.9			
2	92	26.8	85	28.2	5	20.0	2	11.8	8	15.098	n.s.
3	85	24.8	70	23.3	9	36.0	6	35.3			
≥4	80	23.3	64	21.3	8	32.0	8	47.1			
Remittances received											
Yes	196	57.1	162	53.8	20	80.0	14	82.4	2	11.102	0.004
No	147	42.9	139	46.2	5	20.0	3	17.6			
Owns plough											
Yes	253	74.2	216	72.2	20	80.0	17	100.0	2	6.949	0.031
No	88	25.8	83	27.8	5	20.0	0	0.0			
Owns draft cattle											
Yes	199	60.7	163	57.0	20	80.0	16	94.1	2	13.506	0.001
No	129	39.3	123	43.0	5	20.0	1	5.9			
Owns goats											
Yes	262	79.9	224	78.3	22	88.0	16	94.1	2	3.602	n.s.
No	66	20.1	62	21.7	3	12.0	1	5.9			
Owns bicycle											
Yes	63	18.5	49	16.4	9	36.0	5	29.4	2	7.312	0.026
No	278	81.5	250	83.6	16	64.0	12	70.6			
Owns radio											
Yes	93	27.3	74	24.7	11	44.0	8	47.1	2	7.842	0.020
No	248	72.3	225	75.3	14	56.0	9	52.9			
Owns sewing machine											
Yes	34	10.0	23	7.7	7	28.0	4	23.5	2	14.264	0.001
No.	307	90.0	276	92.3	18	72.0	13	76.5			

***Table 4.4.4a** Association between household socio-economic status (SES) and socio-economic characteristics*

Socio-economic characteristics by household SES											
	Total Sample n=343		Tercile I n=114		Tercile II n=115		Tercile III n=114		Chi-square statistic		
No. income sources	n	%	n	%	n	%	n	%	df	χ^2	p
Subsistence only	17	5.0	14	12.3	2	1.7	1	0.9			
1	69	20.1	23	20.2	28	24.3	18	15.8			
2	92	26.8	33	28.9	32	27.8	27	23.7	8	29.836	<0.001
3	85	24.8	28	24.6	25	21.7	32	28.1			
≥4	80	23.3	16	14.0	28	24.3	36	31.6			
Remittances received											
Yes	196	57.1	45	39.5	64	55.7	87	76.3	2	31.749	<0.001
No	147	42.9	69	60.5	51	44.3	27	23.7			
Owns plough											
Yes	253	74.2	76	66.7	86	76.1	91	79.8	2	5.477	n.s.
No	88	25.8	38	33.3	27	23.9	23	20.2			
Owns draft cattle											
Yes	199	60.7	48	46.6	65	58.0	86	76.1	2	20.153	<0.001
No	129	39.3	55	53.4	47	42.0	27	23.9			
Owns goats											
Yes	262	79.9	78	75.7	92	82.1	92	81.4	2	1.627	n.s.
No	66	20.1	25	24.3	20	17.9	21	18.6			
Owns bicycle											
Yes	63	18.5	18	15.8	19	16.7	26	23.0	2	2.336	n.s.
No	278	81.5	96	84.2	95	83.3	87	77.0			
Owns radio											
Yes	93	27.3	21	18.4	31	27.2	41	36.3	2	9.129	0.010
No	248	72.7	93	81.6	83	72.8	72	63.7			
Owns sewing machine											
Yes	34	10.0	8	7.0	9	7.9	17	15.0	2	4.895	n.s.
No.	307	90.0	106	93.0	105	92.1	96	85.0			

Table 4.4.4b *Association between household socio-economic status (SES) and socio-economic characteristics*

Socio-economic characteristics by agro-ecological zone											
Socio-economic characteristics	**Total Sample n=293**		**Zone III n=99**		**Zone IV n=117**		**Zone V n=77**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
No. hectares cropped 1993/4	2.3	1.5	1.9	1.1	2.8	1.8	1.9	1.3	2	14.419	<0.001
Per capita hectares cropped 93/4	0.44	0.28	0.40	0.25	0.55	0.31	0.34	0.21	2	16.485	<0.001
No. hectares cropped 94/5	2.3	1.8	1.9	1.1	2.8	2.2	1.8	1.5	2	11.059	<0.001
Per capita hectares cropped 94/5	0.43	0.28	0.40	0.24	0.52	0.32	0.33	0.22	2	14.471	<0.001
Annual income *per capita* (Z$)	700.4	746.0	953.5	988.7	710.5	667.1	415.2	348.1	2	14.393	<0.001
Total value of Livestock (Z$)	6,081.9	7052.9	8,293.9	7,624.1	5,639.4	7,104.0	4,317.2	5,662.6	2	8.633	<0.001
No. cattle	4.9	5.2	6.6	5.6	4.8	5.1	3.3	4.4	2	10.107	<0.001
No. goats	4.8	6.2	2.8	2.7	4.9	4.9	6.7	9.3	2	9.750	<0.001
No. agricultural assets	6.2	3.0	7.2	3.5	6.1	2.6	5.3	2.8	2	10.039	<0.001
No. household assets	3.5	2.6	4.3	2.9	3.0	2.2	3.2	2.5	2	9.165	<0.001

Socio-economic characteristics by agro-ecological zone							
Socio-economic characteristics	**Total Sample n=349**	**Zone III n=106**	**Zone IV n=142**	**Zone V n=101**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
No. hectares cropped 1993/4	1.82	1.62	2.22	1.62	2	24.476	<0.001
Per capita hectares cropped 93/4	0.35	0.31	0.46	0.27	2	27.300	<0.001
No. hectares cropped 94/5	1.62	1.62	2.03	1.62	2	21.336	<0.001
Per capita hectares cropped 94/5	0.36	0.33	0.46	0.25	2	29.216	<0.001
Annual income *per capita* (Z$)	483.1	607.7	520.3	299.9	2	34.206	<0.001
Total value of Livestock (Z$)	4,302.5	6,500	4,215	1,435	2	12.996	0.002
No. cattle	4.0	6.0	4.0	2.0	2	20.486	<0.001
No. goats	4.0	2.0	4.0	5.0	2	24.907	<0.001
No. agricultural assets	6.0	7.0	6.0	5.0	2	17.812	<0.001
No. household assets	3.0	4.0	2.0	2.0	2	14.768	0.001

Table 4.4.5 *Association between agro-ecological zone and socio-economic characteristics*

Socio-economic characteristics by agro-ecological zone											
	Total Sample		Zone III		Zone IV		Zone V		Chi-square statistic		
No. income sources	n	%	n	%	n	%	n	%	df	χ^2	p
Subsistence only	17	5.0	8	7.5	3	2.2	6	1.7			
1	69	20.1	13	12.3	34	24.6	22	22.2			
2	92	26.8	30	28.3	29	21.0	33	33.3	8	15.976	0.043
3	85	24.8	31	29.2	34	24.6	20	20.2			
≥4	80	23.3	24	22.6	38	27.5	18	18.2			
Remittances received											
Yes	196	57.1	51	48.1	88	63.8	57	57.6	2	6.010	0.050
No	147	42.9	55	51.9	50	36.2	42	42.4			
Owns plough											
Yes	254	73.4	76	71.7	108	77.1	70	70.0	2	1.754	n.s.
No	92	26.6	30	28.3	32	22.9	30	30.0			
Owns draft cattle											
Yes	129	39.3	26	25.5	52	39.7	51	53.7	2	16.398	<0.001
No	199	60.7	76	74.5	79	60.3	44	46.3			
Owns goats											
Yes	262	79.9	73	71.6	109	83.2	80	84.2	2	6.394	0.041
No	66	20.1	29	28.4	22	16.8	15	15.8			
Owns bicycle											
Yes	63	18.3	23	21.7	24	17.3	16	16.0	2	1.274	n.s.
No	282	81.7	83	78.3	115	82.7	84	84.0			
Owns radio											
Yes	93	27.0	38	35.8	30	21.6	25	25.0	2	6.490	0.039
No	252	73.0	68	64.2	109	78.4	75	75.0			
Owns sewing machine											
Yes	34	9.9	12	11.3	12	8.6	10	10.0	2	0.492	n.s.
No.	311	90.1	94	88.7	127	91.4	90	90.0			

Table 4.4.6 *Association between agro-ecological zone and socio-economic characteristics*

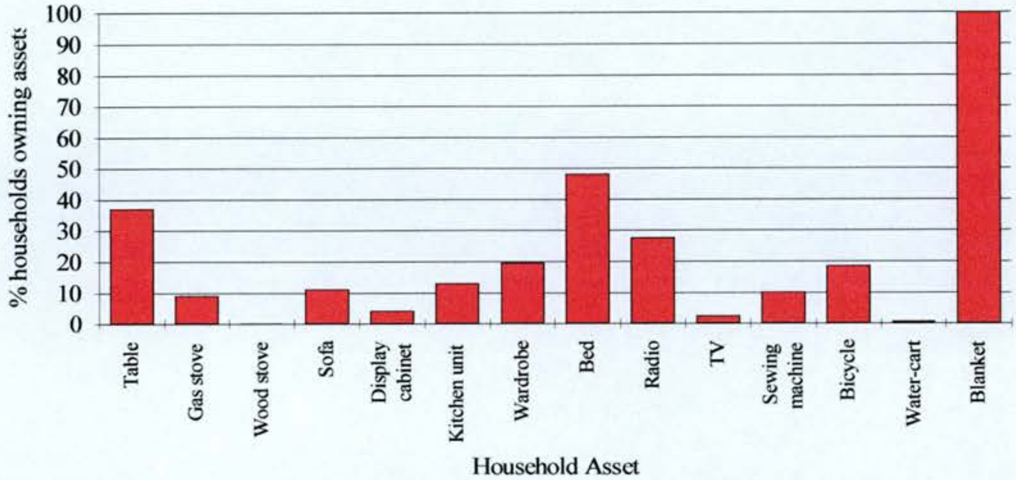


Figure 4.1: *Percentage of households owning various domestic assets*

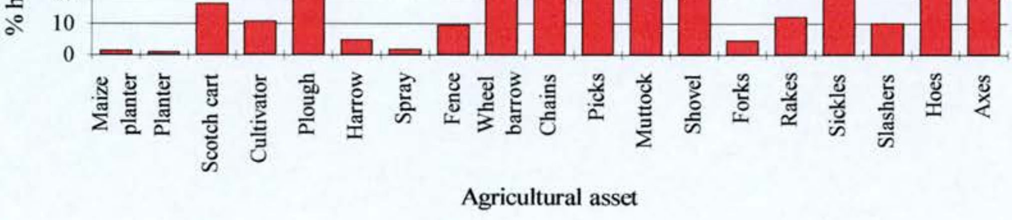


Figure 4.2: *Percentage of households owning various agricultural assets*

Tables for section 4.5 Food security status and dietary consumption patterns by household type

Food security status and dietary consumption patterns by gender of household head											
Food security indicator	**Total Sample n=349**		**Male n=192**		***De facto* female n=107**		***De jure* female n=50**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Per capita maize (kg) 93/94	198.0	392	183.2	414.5	232.2	344.4	181.7	404.0	2	0.460	n.s.
No. days maize supplies *per capita*	330	653.3	305.3	690.8	387.0	574.1	302.8	673.2	2	0.460	n.s.
No days extra *pcapita* 94 inc. drought cr	63.9	66.4	69.6	77.0	52.5	43.3	60.9	47.5	2	1.436	n.s.
Per capita maize (kg) 94/5	102.8	209.7	88.6	215.2	136.9	225.3	79.9	119.3	2	1.399	n.s.
No. days maize supplies *per capita* 95	171.3	349.5	147.7	358.6	228.2	375.6	133.1	198.8	2	1.399	n.s.
No days extra *pcapita* 95 inc. drought cr	60.9	124.2	49.4	93.5	87.2	194.4	70.9	95.1	2	1.421	0.137
No. meals per day *post-harvest 94*	3.1	0.9	3.1	0.9	3.4	1.0	2.8	0.7	2	6.687	0.001
No. FVS* *post-harvest Jul-Oct 94*	30.5	10.3	30.5	10.2	32.0	10.3	27.4	10.2	2	3.333	0.037
No. DDS† *post-harvest Jul-Oct 94*	9.97	1.46	9.95	1.33	10.25	1.33	9.45	1.97	2	5.208	0.006
No. meals per day *pre-harvest 95*	2.9	0.9	2.9	0.9	3.2	0.9	2.6	1.0	2	5.558	0.004
No. FVS *pre-harvest Nov94- Feb95*	26.4	9.1	26.5	8.9	27.5	9.2	24.0	9.6	2	2.278	n.s.
No. DDS *pre-harvest Nov94- Feb95*	9.63	1.87	9.62	1.79	9.84	1.85	9.20	2.18	2	1.782	n.s.
No. meals per day *harvest 95*	2.7	0.6	2.7	0.6	2.8	0.6	2.6	0.6	2	1.270	n.s.
No. FVS *harvest Mar95-Jun95*	23.2	9.7	23.8	9.8	23.2	8.9	21.2	10.4	2	1.334	n.s.
No. DDS *harvest Mar95-Jun95*	9.11	1.83	9.11	1.71	9.35	1.93	8.71	2.05	2	1.746	n.s.
No. meals per day *post-harvest 95*	2.7	0.7	2.7	0.7	2.8	0.6	2.6	0.8	2	1.677	n.s.
No. FVS *post-harvest Jul-Oct 95*	20.2	7.6	20.2	7.1	20.5	8.0	19.8	8.7	2	0.140	n.s.
No. DDS *post-harvest Jul-Oct 95*	8.50	1.86	8.50	1.74	8.75	1.90	8.04	2.15	2	2.189	n.s.

Food security indicators	**Total Sample**	**Male**	***De facto* female**	***De jure* female**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
Per capita maize (kg) 93/94	74.3	68.5	91.0	61.6	2	4.688	n.s.
No. days maize supplies *per capita*	123.9	114.2	151.7	102.7	2	4.688	n.s.
No. days maize & small grain *pcapita* 94	45.7	45.8	37.9	43.4	2	0.967	n.s.
Per capita maize (kg) 94/5	56.9	55.9	75.8	50.6	2	5.084	n.s.
No. days maize supplies *per capita* 95	34.1	55.9	75.8	50.6	2	5.084	n.s.
No. days maize & small grain capita 95	27.9	25.3	28.3	37.8	2	1.986	n.s.

Table 4.5.1: *Food security status & dietary consumption patterns by gender of household head. *FVS-Food variety score; †DDV-Dietary diversity score*

Food security status and dietary consumption patterns by household SES

Food security indicator	Total Sample n=343		Very poor n=301		Poor n=25		Non-poor n=17		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Per capita maize (kg) 93/94	198.0	392.0	113.4	149.5	463.3	519.4	1,023.6	1,007.3	2	73.995	<0.001
No. days maize supplies *per capita*	330	653.3	189.0	249.2	772.2	865.6	1,706.0	1,678.9	2	73.995	<0.001
No days extra *pcapita* 94 inc. drought cr	63.9	66.4	61.6	63.0	97.4	116.9	77.1	67.9	2	1.570	n.s.
Per capita maize (kg) 94/5	102.8	209.7	60.6	101.1	260.0	278.2	440.3	534.2	2	38.131	<0.001
No. days maize supplies *per capita* 95	171.3	349.5	101.0	168.5	433.4	463.7	733.8	890.3	2	38.131	<0.001
No days extra *pcapita* 95 inc. drought cr	60.9	142.2	57.2	101.6	145.9	340.0	15.9	21.2	2	2.482	n.s.
No. meals per day *post-harvest* 94	3.1	0.9	3.1	0.9	3.6	0.9	3.5	0.8	2	4.641	0.010
No. FVS* *post-harvest Jul-Oct 94*	30.5	10.3	30.0	10.4	34.1	9.4	34.1	7.0	2	2.938	n.s.
No. DDS† *post-harvest Jul-Oct 94*	9.97	1.46	9.90	1.48	10.6	1.10	10.35	1.37	2	3.439	0.033
No. meals per day *pre-harvest* 95	2.9	0.9	2.9	0.9	3.4	0.9	3.5	0.8	2	7.076	0.001
No. FVS *pre-harvest* Nov94- Feb95	26.5	9.2	26.1	9.4	29.9	9.1	28.6	5.1	2	2.351	n.s.
No. DDS *pre-harvest* Nov94- Feb95	9.63	1.87	9.56	1.94	10.17	1.17	10.06	1.23	2	1.665	n.s.
No. meals per day *harvest* 95	2.7	0.6	2.7	0.6	2.9	0.5	2.9	0.8	2	0.926	n.s.
No. FVS *harvest* Mar95-Jun95	23.2	9.7	23.0	9.8	23.5	7.8	27.6	9.8	2	1.772	n.s.
No. DDS *harvest* Mar95-Jun95	9.11	1.84	9.03	1.89	9.36	1.56	10.06	0.77	2	2.628	n.s.
No. meals per day *post-harvest* 95	2.7	0.7	2.7	0.7	3.0	0.7	2.9	0.6	2	3.195	0.042
No. FVS *post-harvest* Jul-Oct 95	20.2	7.6	19.9	7.6	22.3	7.1	22.9	7.1	2	2.122	n.s.
No. DDS *post-harvest* Jul-Oct 95	8.50	1.86	8.41	1.91	8.96	1.36	9.19	1.28	2	2.083	n.s.
Food security indicators	**Total Sample**	**Very Poor**	**Poor**	**Non-poor**	**Kruskal-Wallis**		
	Median	Median	Median	Median	df	H	*p*
Per capita maize (kg) 93/94	74.3	60.7	223.0	630.0	2	40.793	<0.001
No. days maize supplies *per capita*	123.9	101.1	371.6	1,050.0	2	40.793	<0.001
No days extra *pcapita* 95 inc. drought cr	45.7	43.3	61.6	55.3	2	0.908	n.s.
Per capita maize (kg) 94/5	34.1	30.3	159.3	236.3	2	34.916	<0.001
No. days maize supplies *per capita* 95	56.9	50.6	265.4	393.8	2	34.916	<0.001
No days extra *pcapita* 95 inc. drought cr	27.9	28.3	25.3	7.6	2	3.536	n.s.

Table 4.5.2a: *Food security status & dietary consumption patterns by household SES; *FVS-Food variety score; †DDV-Dietary diversity score*

Food security status and dietary consumption patterns by household SES											
Food security indicator	**Total Sample n=343**		**Tercile I n=114**		**Tercile II n=115**		**Tercile III n=114**		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Per capita maize (kg) 93/94	198.0	392	46.0	42.7	99.7	102.0	405.1	581.4	2	27.072	<0.001
No. days maize supplies *per capita*	330.0	653.3	76.6	71.2	166.2	170.0	675.2	969.0	2	27.072	<0.001
No days extra pcapita 94 inc. drought cr	63.9	66.4	53.3	52.7	66.7	73.3	72.8	70.6	2	1.596	n.s.
Per capita maize (kg) 94/5	102.8	209.7	34.7	62.2	49.3	65.6	186.4	298.5	2	14.155	<0.001
No. days maize supplies *per capita* 95	171.3	349.5	57.9	103.6	82.2	109.3	310.6	497.5	2	14.155	<0.001
No days extra pcapita 95 inc. drought cr	60.9	124.2	40.4	66.2	59.9	97.6	90.6	195.9	2	2.166	n.s.
No. meals per day *post-harvest* 94	3.1	0.9	3.0	0.9	3.1	0.8	3.3	0.9	2	3.784	0.024
No. FVS* *post-harvest Jul-Oct 94*	30.5	10.3	27.5	11.6	30.4	8.8	33.6	9.3	2	10.153	<0.001
No. DDS† *post-harvest Jul-Oct 94*	9.97	1.46	9.43	1.74	10.08	1.29	10.39	1.13	2	13.440	<0.001
No. meals per day *pre-harvest* 95	2.9	0.9	2.6	0.8	3.1	1.0	3.1	0.9	2	8.566	<0.001
No. FVS *pre-harvest* Nov94- Feb95	26.5	9.2	22.1	9.7	28.2	8.1	29.3	8.1	2	22.846	<0.001
No. DDS *pre-harvest* Nov94- Feb95	10.35	1.96	9.58	2.44	10.73	1.57	10.75	1.50	2	14.373	<0.001
No. meals per day *harvest* 95	2.7	0.6	2.6	0.6	2.8	0.7	2.8	0.6	2	3.768	0.024
No. FVS *harvest* Mar95-Jun95	23.2	9.7	19.4	9.8	24.9	8.9	25.2	9.3	2	11.764	<0.001
No. DDS *harvest* Mar95-Jun95	10.09	1.84	9.41	2.00	10.42	1.70	10.40	1.68	2	9.870	<0.001
No. meals per day *post-harvest* 95	2.7	0.7	2.6	0.8	2.7	0.7	2.9	0.6	2	6.801	0.001
No. FVS *post-harvest* Jul-Oct 95	20.2	7.6	16.9	7.2	21.5	7.4	22.1	7.2	2	14.988	<0.001
No. DDS *post-harvest* Jul-Oct 95	9.48	1.85	8.65	2.12	9.82	1.58	9.92	1.57	2	15.802	<0.001
Food security indicators	**Total Sample**		**Tercile I**		**Tercile II**		**Tercile III**		**Kruskal-Wallis**		
	Median		Median		Median		Median		df	H	*p*
Per capita maize (kg) 93/94	74.3		34.1		57.8		159.3		2	95.228	<0.001
No. days maize supplies *per capita*	123.9		56.9		96.4		265.4		2	95.228	<0.001
No. days maize & small grain capita 94	45.7		31.8		50.6		51.3		2	2.613	<0.001
Per capita maize (kg) 94/5	34.1		17.0		30.3		64.3		2	34.396	<0.001
No. days maize supplies *per capita* 95	56.9		28.3		50.6		107.1		2	34.396	<0.001
No. days maize & small grain capita 95	27.9		21.0		29.4		34.0		2	5.177	n.s.

Table 4.5.2b: *Food security status & dietary consumption patterns by household SES; *FVS-Food variety score; †DDV-Dietary diversity score*

Food security status and dietary consumption patterns by agro-ecological zone											
Food security indicator	**Total Sample n=349**		**Zone III n=106**		**Zone IV n=142**		**Zone V n=101**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Per capita maize (kg) 93/94	198.0	392.0	395.8	576.8	81.2	91.8	74.2	108.7	2	24.515	<0.001
No. days maize supplies *per capita*	330.0	653.3	658.8	961.3	135.4	153.0	123.7	180.9	2	24.515	<0.001
No. days maize & small grain *pcapita* 94	63.9	66.4	36.8	55.7	58.5	60.0	90.2	72.9	2	11.086	0.001
Per capita maize (kg) 94/5	102.8	209.7	189.0	303.4	46.0	61.2	44.7	92.5	2	14.244	<0.001
No. days maize supplies *per capita* 95	171.3	349.5	316.7	505.7	76.6	101.9	74.5	154.2	2	14.244	<0.001
No. days maize & small grain capita 95	60.9	124.2	17.7	16.7	36.9	31.0	106.4	188.5	2	8.070	<0.001
No. meals per day *post-harvest 94*	3.1	0.9	3.2	0.9	3.2	0.9	2.8	0.8	2	7.769	0.001
No. FVS* *post-harvest Jul-Oct 94*	30.5	10.3	31.6	8.9	30.4	9.4	29.3	12.7	2	1.305	n.s.
No. DDS† *post-harvest Jul-Oct 94*	9.97	1.46	10.30	1.26	10.06	1.09	9.48	1.93	2	8.793	<0.001
No. meals per day *pre-harvest 95*	2.9	0.9	2.9	0.8	3.0	0.9	2.9	1.1	2	1.363	n.s.
No. FVS *pre-harvest Nov94- Feb95*	26.4	9.1	26.1	6.6	29.9	7.6	22.0	11.3	2	22.704	<0.001
No. DDS *pre-harvest Nov94- Feb95*	9.63	1.87	9.29	1.29	10.60	1.23	8.67	2.44	2	38.571	<0.001
No. meals per day *harvest 95*	2.7	0.6	2.7	0.6	2.9	0.7	2.6	0.6	2	4.362	0.014
No. FVS *harvest Mar95-Jun95*	23.2	9.7	25.7	12.2	24.7	6.5	18.5	7.8	2	16.462	<0.001
No. DDS *harvest Mar95-Jun95*	9.11	1.83	8.83	2.10	9.73	0.93	8.65	2.13	2	10.893	<0.001
No. meals per day *post-harvest 95*	2.7	0.7	2.7	0.6	2.7	0.7	2.8	0.8	2	0.645	n.s.
No. FVS *post-harvest Jul-Oct 95*	20.2	7.6	20.3	6.9	23.4	7.2	15.9	6.8	2	29.239	<0.001
No. DDS *post-harvest Jul-Oct 95*	8.50	1.86	8.56	1.47	9.28	1.58	7.42	2.07	2	29.680	<0.001
Food security indicators	**Total Sample**		**Zone III**		**Zone IV**		**Zone V**		**Kruskal-Wallis**		
	Median		Median		Median		Median		df	H	*p*
Per capita maize (kg) 93/94	74.3		169.0		51.3		34.1		2	73.772	<0.001
No. days maize supplies *per capita*	123.9		281.7		85.5		56.9		2	73.772	<0.001
No. days maize & small grain capita 94	45.7		21.0		38.7		75.8		2	38.210	<0.001
Per capita maize (kg) 94/5	56.9		78.0		30.3		11.3		2	25.770	<0.001
No. days maize supplies *per capita* 95	34.1		130.0		50.6		18.9		2	25.770	<0.001
No. days maize & small grain capita 95	27.9		12.1		28.1		73.2		2	21.375	<0.001

Table 4.5.3: *Food security status & dietary consumption patterns by agro-ecological zone. *FVS-Food variety score; †DDV-Dietary diversity score*

Association between gender of household head and food security factors											
	Total sample		Male		*De facto* female		*De jure* female		Chi-square statistic		
	n	%	n	%	n	%	n	%	df	χ^2	p
No meals per day *post-harvest* (Nov-94)											
<3	66	19.8	42	22.1	12	12.0	12	27.3	2	6.023	0.049
≥3	268	80.2	148	77.9	88	88.0	32	72.7			
No meals per day *pre-harvest* (Mar-95)											
<3	108	33.3	68	370	17	17.7	23	52.3	2	18.736	<0.001
≥3	216	66.7	116	63.0	79	82.3	21	47.7			
No meals per day *harvest* (Jul-95)											
<3	92	32.5	53	32.5	20	25.6	19	45.2	2	4.779	n.s.
≥3	191	67.5	110	67.5	58	74.4	23	54.8			
No meals per day *post-harvest* (Nov-95)											
<3	95	32.4	55	33.3	22	26.5	18	40.0	2	2.568	n.s.
≥3	198	67.6	110	66.7	61	73.5	27	60.0			
Used wild foods											
Yes	179	51.3	104	54.2	49	45.8	26	52.0	2	1.940	n.s.
No	170	48.7	88	45.8	58	54.2	24	48.0			
Cropping pattern 1993/4											
<50% maize	151	51.5	96	56.5	33	40.7	22	52.4	2	5.449	n.s.
≥50% maize	142	48.5	74	43.5	48	59.3	20	47.6			
Cropping pattern 1994/5											
<50% maize	167	52.8	106	59.2	37	39.4	24	55.8	2	9.927	0.007
≥50% maize	149	47.2	73	40.8	57	60.6	19	44.2			
Access to grain-store											
Yes	225	64.5	130	67.7	59	55.1	36	72.0	2	6.183	0.045
No	124	35.5	62	32.3	48	44.9	14	28.0			
Access to garden											
Yes	241	77.2	148	81.3	61	70.1	32	74.4	2	4.430	n.s.
No	72	22.8	34	18.7	26	29.9	11	25.6			

Table 4.5.4: *Association between gender of household head and food security factors*

Association between household socio-economic status (SES) and food security factors											
	Total sample		Very poor		Poor		Non-poor		Chi-square statistic		
	n	%	n	%	n	%	n	%	df	χ^2	p
No meals per day *post-harvest* (Nov-94)											
<3	64	19.4	63	21.7	1	4.3	0	0.0	2	8.428	0.015
≥3	266	80.6	227	78.3	22	95.7	17	100			
No meals per day *pre-harvest* (Mar-95)											
<3	108	33.3	103	36.3	3	13.0	2	11.8	2	8.920	0.012
≥3	216	66.7	181	63.7	20	87.0	15	88.2			
No meals per day *harvest* (Jul-95)											
<3	92	32.6	83	34.0	6	26.1	3	20.0	2	1.750	n.s.
≥3	190	67.4	161	66.0	17	73.9	12	80.0			
No meals per day *post-harvest* (Nov-95)											
<3	94	32.3	87	34.4	4	18.2	3	18.8	2	3.853	n.s.
≥3	197	67.7	166	65.6	18	81.8	13	81.3			
Used wild foods											
Yes	178	51.9	163	54.5	12	50.0	3	17.6	2	8.822	0.012
No	162	48.1	136	45.5	13	50.0	14	82.4			
Cropping pattern 1993/4											
<50% maize	151	51.5	138	54.5	8	34.8	5	29.4	2	6.834	0.033
≥50% maize	142	48.2	115	45.5	15	65.2	12	70.6			
Cropping pattern 1994/5											
<50% maize	167	52.8	152	55.1	10	41.7	5	31.3	2	4.747	n.s.
≥50% maize	149	47.2	124	44.9	14	58.3	11	68.8			
Access to grain-store											
Yes	221	64.4	191	63.5	15	60.0	15	88.2	2	4.543	n.s.
No	122	35.6	110	36.5	10	40.0	2	11.8			
Access to garden											
Yes	241	70.3	207	75.8	20	87.0	14	87.5	2	2.505	n.s.
No	102	29.7	66	24.2	5	13.0	2	12.5			

Table 4.5.5a: *Association between household socio-economic status and food security factors*

Association between household socio-economic status (SES) and food security factors											
	Total sample		**Tercile I**		**Tercile II**		**Tercile III**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	p
No meals per day *post-harvest* (Nov-94)											
<3	64	19.4	31	29.0	19	17.0	14	12.6	2	9.967	0.007
≥3	266	80.6	76	71.0	93	83.0	97	87.4			
No meals per day *pre-harvest* (Mar-95)											
<3	108	33.3	48	44.9	34	30.6	26	24.5	2	10.460	0.005
≥3	216	66.7	59	55.1	77	69.4	80	75.5			
No meals per day *harvest* (Jul-95)											
<3	92	32.6	41	46.1	24	25.3	28	28.6	2	10.318	0.006
≥3	190	67.4	48	53.9	71	74.7	70	71.4			
No meals per day *post-harvest* (Nov-95)											
<3	94	32.3	43	44.8	33	33.0	18	18.9	2	14.618	0.001
≥3	197	67.7	53	55.2	67	67.0	77	81.1			
Used wild foods											
Yes	178	51.9	60	53.1	67	58.8	51	45.1	2	4.270	n.s.
No	162	48.1	53	46.9	47	41.2	62	54.9			
Cropping pattern 1993/4											
<50% maize	151	51.5	58	61.7	60	60.0	33	33.3	2	19.891	<0.001
≥50% maize	142	48.5	36	38.3	40	40.0	66	66.7			
Cropping pattern 1994/5											
<50% maize	167	52.8	65	63.7	65	60.7	37	34.6	2	21.853	<0.001
≥50% maize	149	47.2	37	36.3	42	39.3	70	65.4			
Access to grain-store											
Yes	221	64.4	69	60.5	78	67.8	74	64.9	2	1.348	n.s.
No	122	35.6	45	39.5	37	32.2	40	35.1			
Access to garden											
Yes	241	70.3	78	75.7	81	76.4	82	79.6	2	0.505	n.s.
No	102	29.7	25	24.3	25	23.6	21	20.4			

Table 4.5.5b: *Association between household socio-economic status and food security factors*

Association between agro-ecological zone and food security factors											
	Total sample n=349		**Zone III n=192**		**Zone IV n=107**		**Zone V n=50**		**Chi-square statistic**		
	n	%	n	%	n	%	n	%	df	χ^2	*p*
No meals per day *post-harvest* (Nov-94)											
<3	66	19.8	14	21.2	22	15.9	30	32.6	2	13.450	0.001
≥3	268	80.2	90	86.5	116	84.1	62	67.4			
No meals per day *pre-harvest* (Mar-95)											
<3	108	33.3	40	38.5	30	23.4	38	41.3	2	9.502	0.009
≥3	216	66.7	64	61.5	98	76.6	54	58.7			
No meals per day *harvest* (Jul-95)											
<3	92	32.5	35	35.0	24	24.0	33	39.8	2	5.571	n.s.
≥3	191	67.5	65	65.0	76	76.0	50	60.2			
No meals per day *post-harvest* (Nov-95)											
<3	95	32.4	32	32.3	38	34.9	25	29.4	2	0.648	n.s.
≥3	198	67.6	67	67.7	71	65.1	60	70.6			
Used wild foods											
Yes	179	51.3	51	48.1	78	54.9	50	49.5	2	1.310	n.s.
No	170	48.7	55	51.9	64	37.6	51	50.5			
Cropping pattern 1993/4											
<50% maize	151	51.5	14	14.1	68	58.1	69	89.6	2	102.149	<0.001
≥50% maize	142	48.5	85	85.9	49	41.9	8	10.4			
Cropping pattern 1994/5											
<50% maize	167	52.8	19	19.2	71	54.2	77	89.5	2	91.549	<0.001
≥50% maize	149	47.2	80	80.8	60	45.8	9	10.5			
Access to grain-store											
Yes	225	64.5	63	59.4	94	66.2	68	67.3	2	1.718	n.s.
No	124	35.5	43	40.6	48	33.8	33	32.7			
Access to garden											
Yes	241	69.1	81	81.8	92	72.4	68	79.1	2	3.008	n.s.
No	108	30.9	18	18.2	35	27.6	18	20.9			

Table 4.5.6: *Association between agro-ecological zone and food security factors*

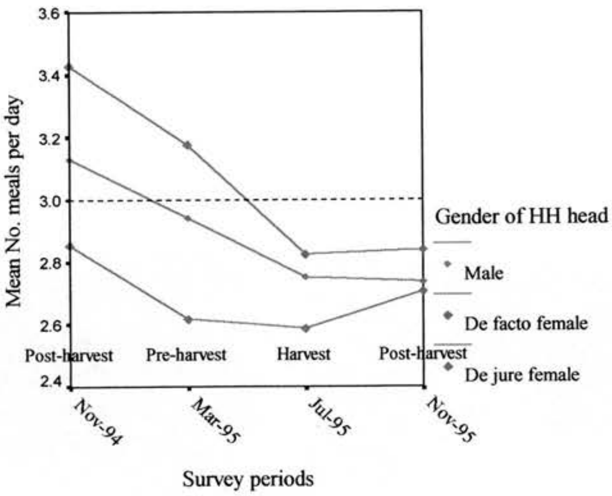


Figure 4.3: *Seasonal variation in mean No. meals consumed per day by gender of household head*

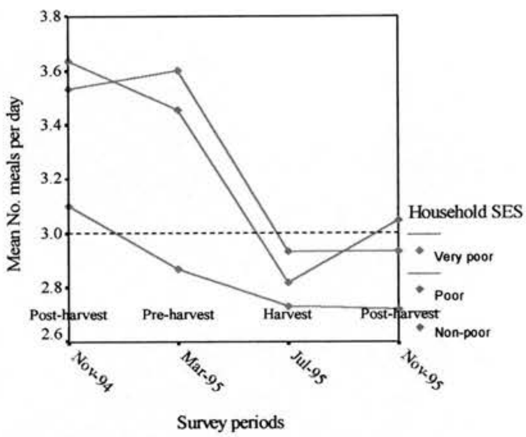


Figure 4.4a: *Seasonal variation in mean No. meals consumed per day analysed by household SES*

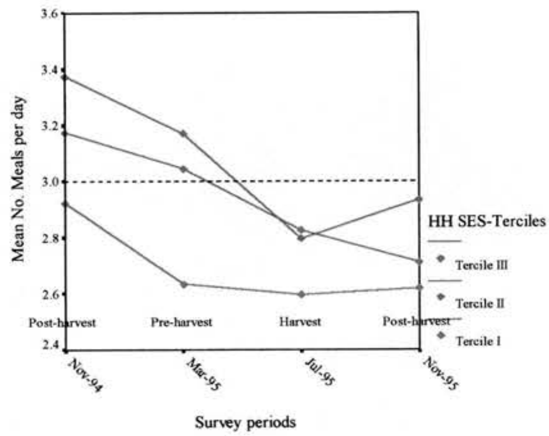


Figure 4.4b: *Seasonal variation in mean No. meals consumed per day analysed by household SES-terciles*

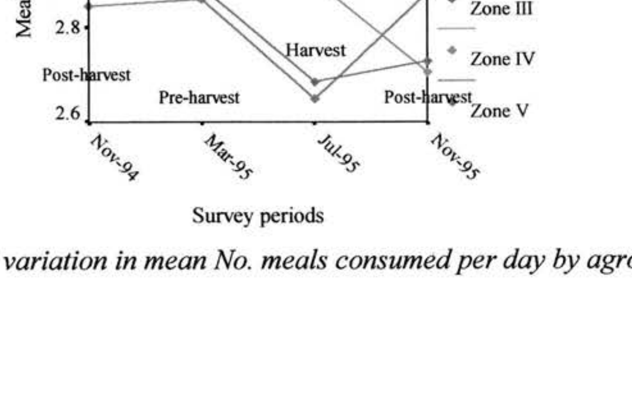


Figure 4.5: *Seasonal variation in mean No. meals consumed per day by agro-ecological zone*

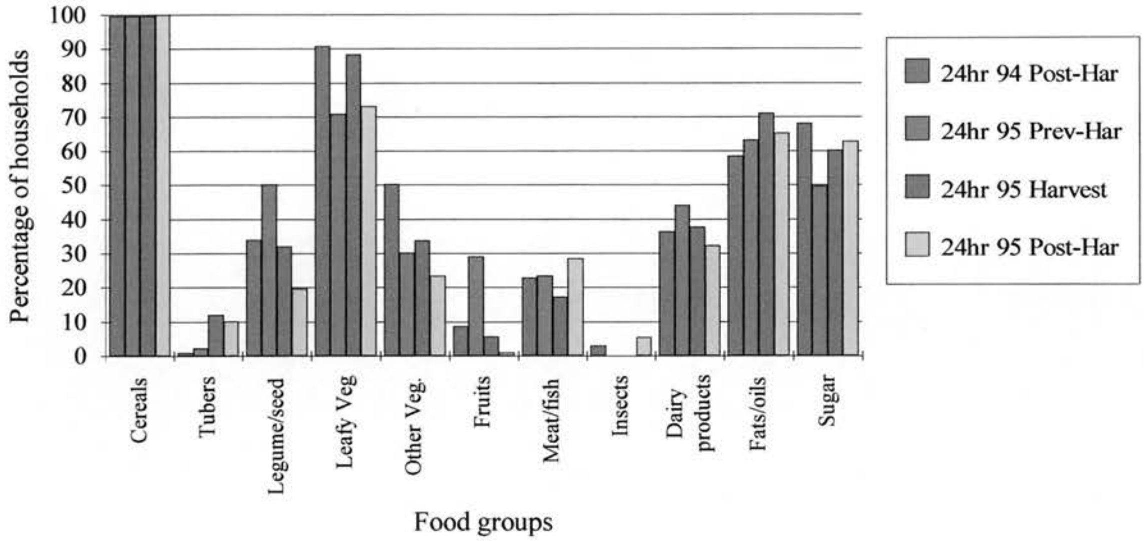


Figure 4.6: *Percentage of households consuming each food group by season (Source: 24 hr recall questionnaires)*

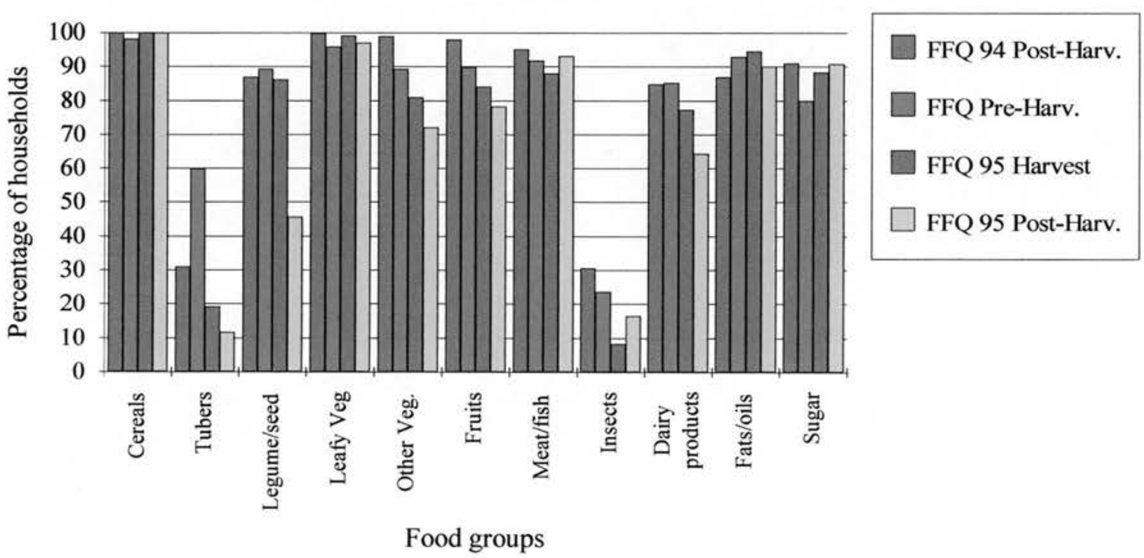


Figure 4.7: *Percentage of households consuming each food group by season (Source: Food frequency questionnaires)*

Fig. 4.8 Proportion of Household 24-hr Qu. Responses by Food Groups
94 Post-harvest Season

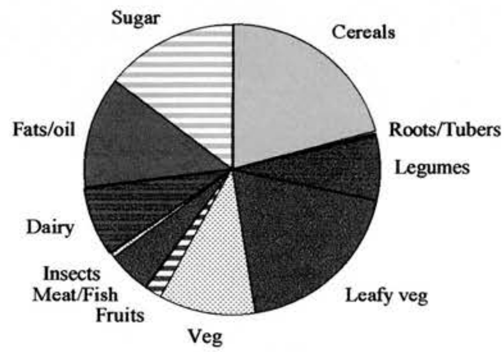


Fig. 4.9 Proportion of Household 24-hr Qu. Responses by Food Groups
95 Pre-harvest Season

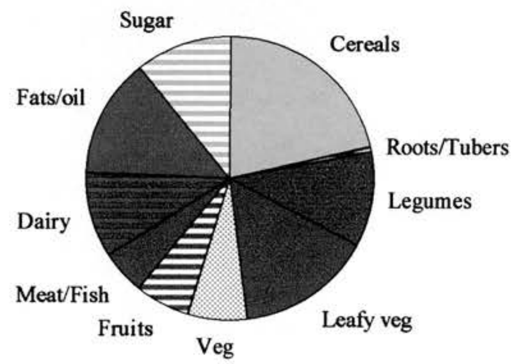


Fig. 4.10 Proportion of Household 24-hr Responses by Food Groups 95 Harvest Season

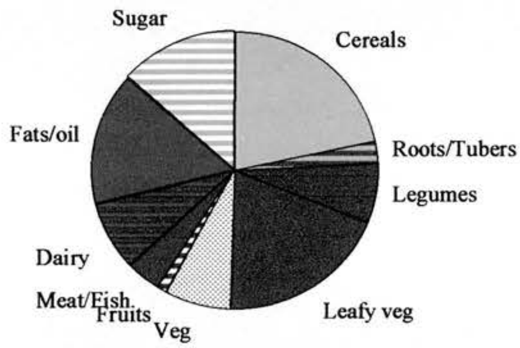
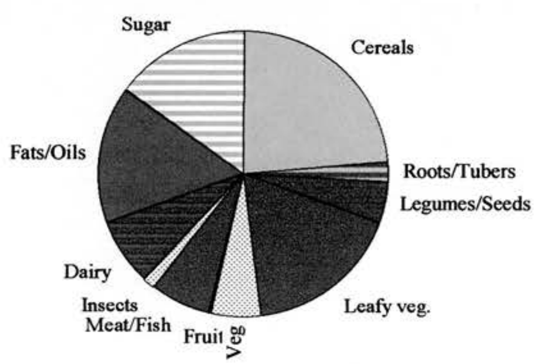


Fig. 4.11 Proportion of Household 24-hr Responses by Food Groups 95 Post-harvest Season



	94 *Post-harvest* Season (Jul-Oct 94)			
	24 hr recall		Food Frequency Questionnaire	
Food rank	**Name of food**	**% HH consuming**	**Name of food**	**% HH consuming**
1	Maize meal (*Zea Mays*)	99.6	Maize meal (*Zea Mays*)	95.3
2	Sugar	68.2	Tomatoes *(Lycopersicon esculentum)*	93.3
3	Cooking oil	56.5	Sugar	91.0
4	Dried green leafy vegetables*	39.3	Onions *(Allium cepa)*	84.5
5	Tomatoes *(Lycopersicon esculentum)*	35.7	Cooking oil	84.5
6	Finger millet *(Eleucine coracana)*	29.5	Chicken *(Gallus gallus)*	82.5
7	Onions *(Allium cepa)*	26.5	Mangai (*Zea Mays) - coarse maize meal*	81.3
8	Fresh milk	24.7	Non-alcoholic beer (made from maize)	76.3
9	Cabbage *(Brassica oleracea)*	22.6	Dried green leafy vegetables*	73.8
10	Peanut butter *(Arachis hypogea)*	20.5	Fresh green leafy vegetables*	73.8
	95 *Pre-harvest* Season (Nov 94 to Feb 95)			
	24 hr recall		**Food Frequency Questionnaire**	
Food rank	**Name of food**	**% HH consuming**	**Name of food**	**% HH consuming**
1	Maize (*Zea Mays*)	96.6	Maize (*Zea Mays*)	93.5
2	Cooking oil	62.6	Cooking oil	91.7
3	Sugar *(Saccharum officinarum)*	49.7	Sugar *(Saccharum officinarum)*	78.7
4	Water melon *(Citrullus lanatus)*	27.8	Chicken *(Gallus gallus)*	76.3
5	Sour milk	26.5	Wild okra *(Corchorus olitorius)*	73.4
6	Pumpkin leaves *(Cucurbita maxima)*	26.2	Sour milk	66.9
7	Fresh milk	25.3	Mangoes *(Mangifera indica)*	63.9
8	Peanut butter *(Arachis hypogea)*	25.3	Groundnuts (*(Arachis hypogea)*	62.1
9	Green maize (*Zea Mays*)	20.1	Goat meat *(Capra spp.)*	61.5
10	Mukakashango *(Coccinia odoensis)*	15.4	Mukakashango *(Coccinia odoensis)*	60.9

Table 4.5.7: *Percentage of households consuming the 10 most frequently consumed foods cited by 24 hr recall and Food frequency questionnaires during the 94 post-harvest and 95 pre-harvest seasons. *Type of green leaf not specified*

	95 *Harvest* Season (Mar-Jun 95)			
	24 hr recall		Food Frequency Questionnaire	
Food rank	**Name of food**	**% HH consuming**	**Name of food**	**% HH consuming**
1	Maize meal *(Zea Mays)*	98.6	Maize meal *(Zea Mays)*	96.3
2	Cooking oil	70.1	Cooking oil	93.9
3	Sugar *(Saccharum officinarum)*	60.2	Green leafy vegetables*	92.5
4	Green leafy vegetables*	44.7	Sugar *(Saccharum officinarum)*	88.4
5	Tomatoes *(Lycopersicon esculentum)*	32.4	Tomatoes *(Lycopersicon esculentum)*	69.7
6	Fresh milk	24.3	Chicken *(Gallus gallus)*	64.3
7	Dried green leafy vegetables*	21.5	Matohwe (Azanza garkeana)	57.5
8	Fresh cabbage *(Brassica oleracea)*	21.5	Peanut butter *(Arachis hypogea)*	57.1
9	Purchased bread *(Triticum vulgare)*	17.6	Purchased bread *(Triticum vulgare)*	56.4
10	Peanut butter *(Arachis hypogea)*	16.5	Mangai *(Zea Mays)*	55.4
	95 *Post-harvest* Season (Jul-Oct 95)			
	24 hr recall		Food Frequency Questionnaire	
Food rank	**Name of food**	**% HH consuming**	**Name of food**	**% HH consuming**
1	Maize meal *(Zea Mays)*	96.9	Maize meal *(Zea Mays)*	99.0
2	Cooking oil	63.6	Sugar *(Saccharum officinarum)*	90.8
3	Sugar *(Saccharum officinarum)*	61.2	Cooking oil	89.4
4	Dried green leafy vegetables*	19.7	Dried green leafy vegetables*	74.9
5	Fresh cabbage *(Brassica oleracea)*	19.7	Mangai *(Zea Mays) - coarse maize meal*	73.3
6	Purchased wheat flour *(Triticum vulgare)*	15.6	Rape *(Brassica spp.)*	72.3
7	Dried Kapenta (Fish) *(Stolothrissa tanganicae)*	15.6	Dried Kapenta (Fish) *(Stolothrissa tanganicae)*	68.6
8	Purchased bread *(Triticum vulgare)*	15.3	Chicken *(Gallus gallus)*	66.0
9	Fresh milk	14.6	Purchased wheat flour *(Triticum vulgare)*	63.7
10	Tomatoes *(Lycopersicon esculentum)*	13.9	Tomatoes *(Lycopersicon esculentum)*	53.3

Table 4.5.8: *Percentage of households consuming the 10 most frequently consumed foods cited by 24 hr recall and Food frequency questionnaires during the 95 harvest and post-harvest seasons. *Vegetable not specified*

Tables for section 4.6 Environmental factors by household type

Association between gender of household head and environmental factors											
	Total sample n=349		Male n=192		*De facto* female n=107		*De jure* female n=50		Chi-square statistic		
Environmental factors	n	%	n	%	n	%	n	%	df	χ^2	p
Type of dwelling											
Traditional	232	66.5	143	74.5	59	55.1	30	60.0			
Mixed	84	24.1	31	16.1	36	33.7	17	34.0	4	16.350	0.003
Modern	33	9.5	18	9.4	12	11.2	3	6.0			
Access to sanitation											
No toilet facility	236	67.6	132	68.8	67	62.6	37	74.0			
Pit latrine	38	10.9	21	10.9	13	12.1	4	8.0	4	2.378	n.s.
Blair	75	21.5	39	20.3	27	25.2	9	18.0			
Access to potable water *Pre-harvest* season											
Protected	136	39.4	68	35.6	46	42.3	24	48.0			
Unprotected	142	41.2	83	43.5	41	39.4	18	36.0	4	3.104	n.s.
Mixed	67	19.4	40	20.9	19	18.3	8	16.0			
Access to potable water *Harvest* season											
Protected	122	35.2	62	32.3	40	38.1	20	40.0			
Unprotected	122	35.2	68	35.4	34	32.4	20	40.0	4	3.628	n.s.
Mixed	103	29.7	62	32.3	31	29.5	10	20.0			
Access to potable water *Post-harvest* season											
Protected	144	41.5	70	36.5	51	48.6	23	46.0			
Unprotected	97	28.0	53	27.6	28	26.7	16	32.0	4	7.221	n.s.
Mixed	106	30.5	69	35.9	26	24.8	11	22.0			

Table 4.6.1: *Association between gender of household head and environmental factors*

Association between household socio-economic status household and environmental factors											
	Total sample n=343		Very poor n=301		Poor n=25		Non-poor n=17		Chi-square statistic		
Environmental factors	n	%	n	%	n	%	n	%	df	χ^2	p
Type of dwelling											
Traditional	229	66.8	211	70.1	13	52.0	5	29.4			
Mixed	82	23.9	66	21.9	9	36.0	7	41.2	4	17.147	0.002
Modern	32	9.3	24	8.0	3	12.0	5	29.4			
Access to sanitation											
No toilet facility	233	67.9	210	69.8	14	56.0	9	52.9			
Pit latrine	37	10.8	31	10.3	5	20.0	1	5.9	4	7.154	n.s.
Blair	73	21.3	60	19.9	6	24.0	7	41.2			
Access to potable water											
***Pre-harvest* season**											
Protected	134	39.4	119	39.9	6	24.0	9	53.0			
Unprotected	140	41.2	125	41.9	10	40.0	5	29.4	4	6.766	n.s.
Mixed	66	19.4	54	18.1	9	36.0	3	17.6			
Access to potable water											
***Harvest* season**											
Protected	119	34.8	102	34.0	8	32.0	9	53.0			
Unprotected	120	35.1	107	35.7	9	36.0	4	23.5	4	2.680	n.s.
Mixed	103	30.1	91	30.3	8	32.0	4	23.5			
Access to potable water											
***Post-harvest* season**											
Protected	140	40.9	125	41.6	9	36.0	8	47.1			
Unprotected	96	28.1	86	28.7	6	24.0	3	17.6	4	2.078	n.s.
Mixed	106	31.0	89	29.7	10	40.0	6	35.4			

Table 4.6.2a: *Association between household SES and environmental factors*

Association between household socio-economic status household and environmental factors											
	Total sample n=343		Tercile I n=114		Tercile II n=115		Tercile III n=114		Chi-square statistic		
Environmental factors	n	%	n	%	n	%	n	%	df	χ^2	p
Type of dwelling											
Traditional	229	66.8	85	74.6	80	69.6	64	56.1			
Mixed	82	23.9	22	19.3	27	23.5	33	28.9	4	11.079	0.026
Modern	32	9.3	7	6.1	8	7.0	17	14.9			
Access to sanitation											
No toilet facility	233	67.9	85	74.6	79	68.7	69	60.5			
Pit latrine	37	10.8	10	8.8	14	13.8	13	35.1	4	6.202	n.s.
Blair	73	21.3	19	16.7	22	19.1	32	28.1			
Access to potable water *Pre-harvest* season											
Protected	134	39.4	50	43.9	39	34.5	45	39.8			
Unprotected	140	41.2	43	37.7	52	46.0	45	39.8	4	2.399	n.s.
Mixed	66	19.4	21	43.9	22	19.5	23	20.4			
Access to potable water *Harvest* season											
Protected	119	34.8	46	40.4	32	28.0	41	36.0			
Unprotected	120	35.1	40	35.1	41	36.0	39	34.2	4	5.054	n.s.
Mixed	103	30.1	28	24.6	41	36.0	34	29.8			
Access to potable water *Post-harvest* season											
Protected	142	41.5	48	42.1	47	41.2	47	41.2			
Unprotected	95	27.8	35	30.7	34	29.8	41	22.8	4	3.151	n.s.
Mixed	105	30.7	31	27.2	33	28.9	26	36.0			

Table 4.6.2b: *Association between household SES-Terciles and environmental factors*

Association between agro-ecological zone and environmental factors											
	Total sample n=349		Zone III n=192		Zone IV n=107		Zone V n=50		Chi-square statistic		
Environmental factors	n	%	n	%	n	%	n	%	df	χ^2	p
Type of dwelling											
Traditional	232	66.5	66	62.3	93	65.5	73	72.3			
Mixed	84	24.1	30	28.3	36	25.4	18	17.8	4	3.374	n.s.
Modern	33	9.5	10	9.4	13	9.2	10	9.9			
Access to sanitation											
No toilet facility	236	67.6	68	64.2	103	72.5	65	64.4			
Pit latrine	38	10.9	7	6.6	21	14.8	10	9.9	4	13.666	0.008
Blair	75	21.5	31	29.2	18	12.7	26	25.7			
Access to potable water *Pre-harvest* season											
Protected	136	39.4	60	56.6	40	28.8	36	36.0			
Unprotected	142	41.2	27	25.5	61	43.9	54	54.0	4	32.005	<0.001
Mixed	67	19.4	19	17.9	38	27.3	10	10.0			
Access to potable water *Harvest* season											
Protected	122	35.2	52	49.1	39	27.7	31	31.0			
Unprotected	122	35.2	24	22.6	45	31.9	47	47.0	4	23.639	<0.001
Mixed	103	29.7	30	28.3	57	40.4	22	22.0			
Access to potable water *Post-harvest* season											
Protected	144	41.5	55	51.9	49	34.8	40	40.0			
Unprotected	97	28.0	21	19.8	32	22.7	44	44.0	4	31.233	<0.001
Mixed	106	30.5	30	28.3	60	42.6	16	16.0			

Table 4.6.3: *Association between agro-ecological zone and environmental factors*

Tables for section 4.7 Location characteristics by household type

Location characteristics by gender of household head											
	Total Sample n=349		**Male n=192**		***De facto* female n=107**		***De jure* female n=50**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Location factors											
Distance to District hospital	33.5	14.5	33.9	14.2	32.7	15.6	33.4	13.4	2	0.209	n.s.
Distance to rural hospital	24.9	14.5	24.9	14.6	25.8	14.1	23.0	15.0	2	0.537	n.s.
Distance to rural clinic	10.3	5.0	9.8	5.1	11.3	4.7	10.3	5.3	2	2.609	n.s.
Distance to outreach post	5.8	3.0	5.8	3.0	6.0	3.2	5.6	2.8	2	0.306	n.s.
Distance to market	6.9	4.0	6.8	3.9	7.4	4.4	6.6	3.7	2	1.128	n.s.
Association between gender of household head and location factors											
Remoteness	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**df**	χ^2	***p***
Not remote	174	49.9	102	53.1	55	51.4	17	34.0	2	5.951	0.051
Remote	175	50.1	90	46.9	52	48.6	33	66.0			

***Table 4.7.1**: Association between gender of household head and remoteness of household*

Location characteristics by household socio-economic status (SES)											
	Total Sample n=343		**Very poor n=301**		**Poor n=25**		**Non-poor n=17**		**ANOVA**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Location factors											
Distance to District hospital	33.5	14.6	32.2	14.3	40.7	14.6	42.0	13.0	2	6.929	0.001
Distance to rural hospital	24.7	14.5	23.4	14.1	29.7	14.4	37.9	13.2	2	9.983	<0.001
Distance to rural clinic	10.3	5.1	10.0	5.0	11.6	5.7	12.5	3.7	2	2.651	n.s.
Distance to outreach post	5.8	3.0	5.6	3.0	6.7	2.7	7.8	2.5	2	5.515	0.004
Distance to market	6.9	4.0	7.0	4.0	6.9	4.7	6.1	3.6	2	0.379	n.s.
Location characteristics by household socio-economic status (SES)											
Remoteness	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**df**	χ^2	***p***
Not remote	173	50.4	145	48.2	13	52.0	15	88.2	2	10.358	0.006
Remote	170	49.6	156	51.8	12	48.0	2	11.8			

***Table 4.7.2a**: Association between gender of household head and remoteness of household*

Location characteristics by household socio-economic status (SES)											
	Total Sample n=343		Tercile I n=114		Tercile II n=115		Tercile III n=114		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Location factors											
Distance to District hospital	33.5	14.6	31.6	15.1	32.1	13.7	36.5	14.6	2	3.352	0.036
Distance to rural hospital	24.7	14.5	22.6	15.3	22.5	13.0	28.8	14.5	2	6.310	0.002
Distance to rural clinic	10.3	5.1	9.6	5.1	9.9	5.3	11.3	4.6	2	3.305	0.038
Distance to outreach post	5.8	3.0	5.4	3.3	5.5	2.9	6.4	2.8	2	3.222	0.041
Distance to market	6.9	4.0	6.2	3.3	7.4	4.0	7.1	4.6	2	2.674	n.s.
Location characteristics by household socio-economic status (SES)											
Remoteness	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**df**	χ^2	***p***
Not remote	173	50.4	59	51.8	50	43.5	64	56.1	2	3.790	n.s.
Remote	170	49.6	55	48.2	65	56.5	50	43.9			

Table 4.7.2b: *Association between gender of household head and remoteness of household*

Location characteristics by agro-ecological zone											
	Total Sample n=349		Zone III n=192		Zone IV n=107		Zone V n=50		ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	df	F	*p*
Location factors											
Distance to District hospital	33.5	14.5	33.9	14.2	32.7	15.6	33.4	13.4	2	0.209	n.s.
Distance to rural hospital	24.9	14.5	24.9	14.6	25.8	14.1	23.0	15.0	2	0.537	n.s.
Distance to rural clinic	10.3	5.0	9.8	5.1	11.3	4.7	10.3	5.3	2	2.609	n.s.
Distance to outreach post	5.8	3.0	5.8	3.0	6.0	3.2	5.6	2.8	2	0.306	n.s.
Distance to market	6.9	4.0	6.8	3.9	7.4	4.4	6.6	3.7	2	1.128	n.s.
Location characteristics by agro-ecological zone											
Remoteness	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**df**	χ^2	***p***
Not remote	175	50.1	61	57.5	64	45.1	50	49.1	2	3.802	n.s.
Remote	174	49.9	45	42.5	78	54.9	51	50.5			

Table 4.7.3: *Association between agro-ecological zone and location characteristics*

Figures for section 4.8

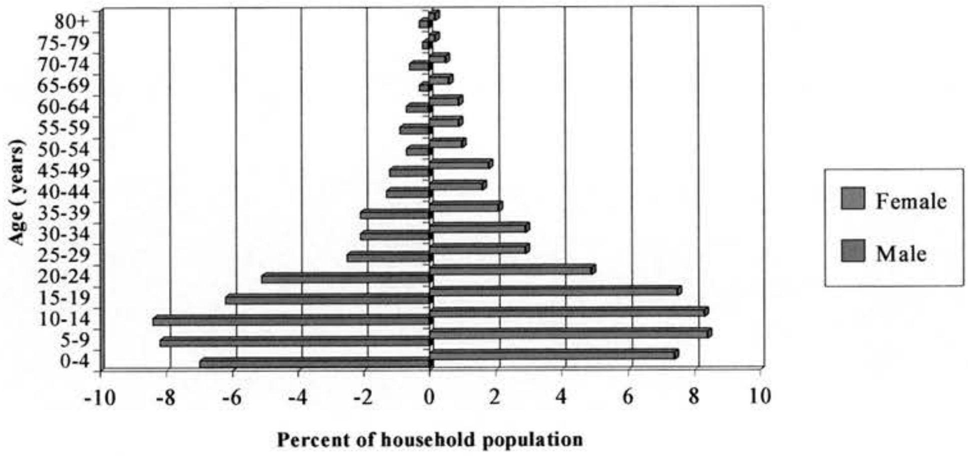


Figure 4.12: *Population pyramid of total household population, de facto and de jure household members with age data combined (n=3,221)*

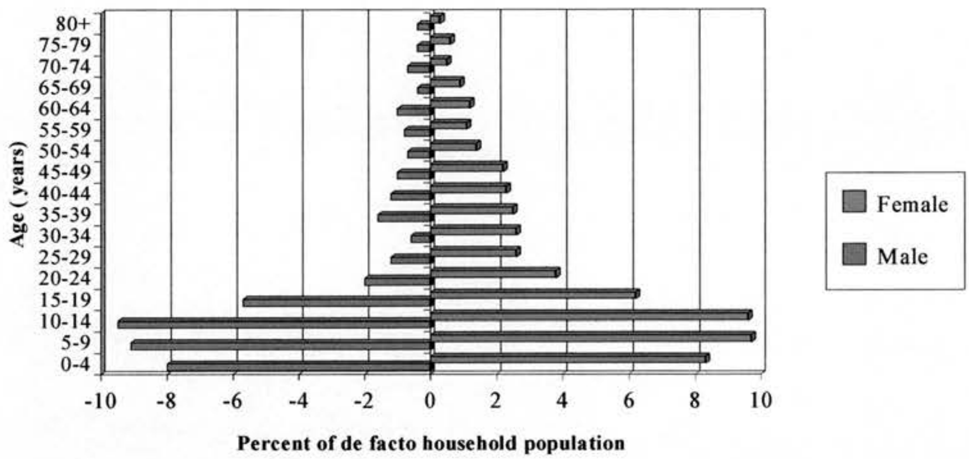


Figure 4.13: *Population pyramid of de facto household members with age data (n=2,084)*

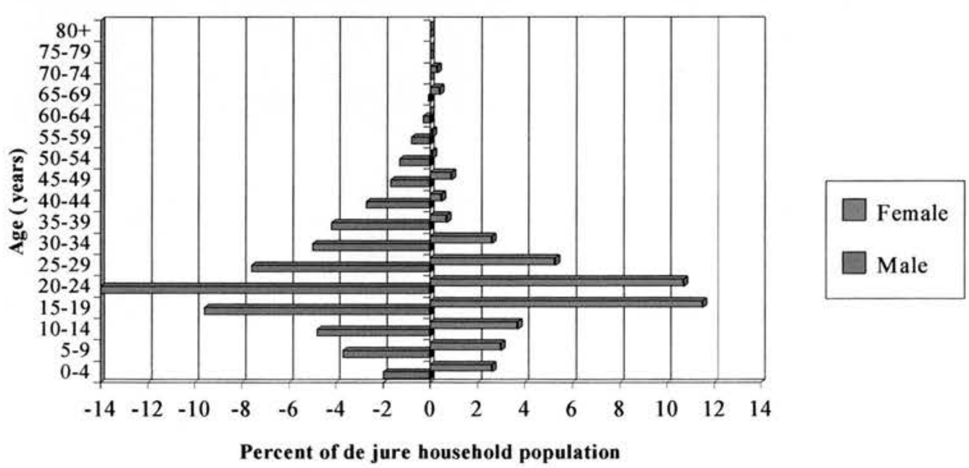


Figure 4.14: *Population pyramid of de jure household population with age data (n=1,137)*

CHAPTER 5 LEVEL OF CHILD AND ADULT CHRONIC MALNUTRITION IN BUHERA DISTRICT, ZIMBABWE

5.1 Introduction

This chapter examined the level of chronic malnutrition amongst children and adults in Buhera District using anthropometry as an indirect proxy for nutritional status. Simultaneously considering adult and child anthropometric data provides an insight into the dynamics of nutritional status throughout the life-span and ecology of the nutritional situation within the community. To maintain optimal sample sizes the baseline anthropometric measurements obtained in Mar-95[1], the largest cross-sectional anthropometric survey were used to describe the pattern of growth throughout the life-span. The prevalence level, severity and pattern of chronic malnutrition within the study population was subsequently diagnosed using anthropometric indicators derived from the anthropometric measures collected in Mar-95. Comparative analyses of the anthropometric measures and indicators within and between the sample population provides an indication of age and gender related differences in growth and nutritional status thereby identifying the demographic profile of the most nutritionally at-risk. In this chapter no attempt is made to describe the seasonal variation in nutritional status (see Chapter 6).

5.2 Variation in participation rates in the anthropometric surveys

The nature of a mixed cross-sectional longitudinal study such as Buhera results in the fluctuation of sample sizes. This section describes the variation in participation rates in the anthropometric surveys. The demographic profile of the individuals measured was compared with those who were not measured, to assess coverage, representativeness and establish sample bias. The participation rate was computed by dividing the number of *de facto* household members measured by the number of *de facto* household members not measured expressed as a percentage. Appendix 3-Tables 5.2.1-5.2.7 and Figure 5.1 summarises the analyses on participation rates.

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[1] *Throughout this thesis the survey months have been shortened to 3 letters each.*

5.2.1 Participation variation by age: The highest rates were observed amongst the primary school aged population (5-9.99 years) and adolescents (10-17.99 years). The lowest rates were observed amongst young adults (18-21.99 years) and the middle-aged (22-59.99 years). There was a significant association between age and participation rates in Mar-95 (p<0.001), Jul-95 (p<0.001) and Nov-95 (p<0.001) (Table 5.2.1). The high participation rates observed amongst the school-aged children was ensured by measuring them at their respective educational institutions. Whereas the relatively lower participation rates amongst young adults and the middle-aged reflects their mobility and economic responsibilities, the majority were actively engaged in agricultural work or off-farm activities.

5.2.2 Participation variation by gender: Overall females had a slightly higher participation rate in all survey rounds, although the gender differences in attendance were statistically insignificant (Table 5.2.2). The gender analyses were repeated within each age group, the disparity in participation rates was most pronounced amongst young adults, middle-age and elderly. Young adult and middle-aged men and elderly females were the most likely sectors to be under-represented.

5.2.3 Participation variation by geographic location, religion and season: Considering the importance of geographical location in this study, the stratified sampling frame had been designed to reflect the proportion of population residing within each agro-ecological zone. Likewise, random selection of households within villages ensured that all households had an equal probability of being chosen irrespective of accessibility. The association between participation rates and agro-ecological zone at the macro level and household accessibility or remoteness at the micro level was examined. A strong association was observed between participation rate and agro-ecological zone throughout the study: Nov-94 (p=0.036), Mar-95 (p<0.001), Jul-95 (p=0.017), Nov-95 (p=0.001) (Table 5.2.3). However, the agro-ecological zone with the lowest and highest participation rates varied by survey round suggesting that there was no systematic bias in geographic representation in the anthropometric surveys. Remote[2] households were generally less likely to participate, although association between accessibility and participation was statistically insignificant and inconsistent throughout the study (Table 5.2.4).

Half the households practised Apostolic faith, a religion that forbids the use of formal curative and preventative health-care, but no association was observed in the variation in participation rates and the practice or non-practice of apostolic religion throughout the study (Table 5.2.6). Also, there was no significant variation in participation rates by season.

5.2.4 Reasons for non-participation by survey round: were categorised into eight groups: outward migration, working, absent from school, sickness or disablement, funeral attendance, newborn, refused, no reason, by survey round (Figure 5.1). Reasons given for non-participation provide an invaluable insight into the seasonal dynamics operating within the community during the study. The number of household members who temporarily migrated from the District increased as the negative effects of the drought ensued. The proportion of children reported absent from school on the scheduled measurement day varied seasonally by location ranging between 6-19%; the highest level of school absenteeism was reported in agro-ecological zone V. Poor school attendance is often used an early warning signal to indicate increased risk of household food insecurity. The involvement of children in the procurement of food (picking wild foods) and earning off-farm income to increase the households' purchasing capacity is common coping strategy used by households to avert household food insecurity. The overall impact of funerals on attendance rates was relatively minor. The reason for non-participation was unknown for a large proportion of the non-attendees. In these cases no other member from the household was present to explain the absenteeism.

5.2.6 Number and proportion of excluded measures by reason and survey round: Details of the standardised procedures used to take the weight, height and MUAC

[2] *Remoteness of the household was determined subjectively by the enumerators (See methodology).*

measurements are documented in Chapter 3. The criterion used to exclude improbable weight and height measures are outlined in Appendix 1. The number and percent of exclusions for each cross-sectional anthropometric survey are summarised in Appendix 1. The major reasons for exclusion was pregnancy or lactation, <1% of the exclusions were due to either measurement error or inaccurate age assessment.

On the basis of the above analysis the anthropometric sample and measurements were considered an accurate representation of the anthropometric status of the Buhera population during 1994/5 agricultural season.

5.2.7 Comparison of the gender and age distribution of study population with anthropometric measures by survey round: Anthropometric data-sets were available for statistical analyses at four time points: Nov-94 (n=443), Mar-95 (n=1,651), Jul-95 (n=1,602) and Nov-95 (n=1,493). The first anthropometric survey (Nov-94) was a trial conducted in only three of the ten wards. Hence the relatively smaller sample size. The remaining three anthropometric surveys were extensive including all selected households. Since Mar-95 was the first inclusive anthropometric survey and also the largest, the measures taken in Mar-95 were used as baseline data in this chapter to describe the nutritional status of child and adult population.

A total of 1,737 household members were measured. Of the 1,737 one household member had no age data and could not be categorised into an age group. An additional 85 measures were excluded due to pregnancy, lactation or measurement problems. The remaining 1,651 household members with measures were divided into six age groups. The gender and age distribution of the anthropometric samples by survey round are summarised in (Appendix 3-Table 5.2.7). As expected from the demographic profile there was a significant female bias in the number of subjects measured (p=0.003). Of the 1,651 household members with measures, 745 (45.7%) were male and 897 (54.2%) were female. In all age groups with the exception of adults aged ≥60 years the number of women measured exceeded the number of men. The gender disparity was most pronounced amongst the middle-aged (22-59 years);

nearly two thirds (63.9%) were female. The lack of an association between gender and participation rates, means that the female bias in this age group is related to outward migration of males rather than poor participation of men. In contrast, the bias towards the young, over two-thirds (67.2%) of the household measured were children (0-17.99 years; n=1,109), was attributed to both the demographic profile of the sample and the significantly higher participation rates observed amongst school children (p<0.001) (Appendix 3-Table 5.2.2).

5.3 The distribution of child and adult weight, height and MUAC

5.3.1 Distribution of mean child (0-22 years) height - gender and age differences:

Figure 5.2 illustrates that male and female child height are fairly similar until eleven years of age; no consistent pattern of height superiority emerges between the sexes until adolescence. Males were on average taller than females between the ages 1-3 years; at 3 years of age the gender difference in mean height was highly significant (p=0.003) (Table 5.3.3). Amongst four year olds females were slightly taller. This alternating pattern of stature superiority between the sexes prevailed during middle-childhood (5-9 years). The observed gender differences within each yearly age class during middle childhood were statistically insignificant (Table 5.3.3). The lack of a consistent higher male mean height observed within the Buhera child population which is usually detected in well nourished populations may be due to the relatively small sample sizes within each yearly age class. Small sample sizes can emphasis between child variance and distort the gender variations in growth.

In constrast, during adolescence distinct gender differences in mean height emerge. Comparing male and female mean height within the adolescent age group it is possible to surmise gender differences in the timing of pubescence and duration of maturation. The red and green arrows in Figure 5.2 indicate the respective cross-over points when female and male height intercept and deviate from each other during pubescence. It is evident that female height velocity supersedes males around 11 years. During the first phase of adolescence (11-12 years) females are consistently taller than males. The gender difference in mean height becomes statistically significant at 12 years

(p=0.007) (Table 5.3.3). The large variation and absolute difference in mean height observed within the female population between the ages of 10-11 years is indicative that on average girls in Buhera enter puberty at around 11 years old. Whereas, variance in mean height within the male adolescent population becomes evident between 12-13 years, suggesting that the male growth spurt starts approximately two years later than females at around 13 years.

During the middle phase of adolescence (14-15 years) females continue to have a superior stature compared to their male counterparts but the gender differences become less pronounced. In the last phase of adolescence female growth slows down and male growth gains momentum as males enter puberty. From 16 years onwards male stature becomes and remains superior to females throughout adulthood. The gender difference in mean height is highly significant from 17 years onwards (Table 5.3.3).

Both male and female height continue to increase beyond 18 years old. This delayed and prolonged maturation is particularly evident amongst males, assuming the cross-sectional traits reflect a longitudinal pattern. The difference between the mean height of 18 and 21 year old males was in excess of 6.0 cm. This prolonged maturation of height within the male sample results in substantial compensatory or *'catch up'* growth. The extended period of maturation amongst the female sample was less pronounced and the duration was seemingly shorter by one year. Since, no data pertaining to sexual maturation was collected in the Buhera study, the exact timing and duration of the puberty can not be substantiated. It is acknowledged that children experience the adolescent growth spurt at widely different chronological ages and therefore it is difficult to infer the exact timing of peak height velocity (PHV). Rather the above analyses provide a broad indication of gender differences in height from infancy, through middle childhood and adolescence within the Buhera population. The impact of age and gender on annual velocity rates are examined in Chapter 6 using the longitudinal sample.

5.3.2 The pattern of growth within each discrete period of childhood: The pattern of growth within and between each of the three discrete periods of childhood: infancy and the pre-school years (0-4.99 years), middle-childhood or primary school population (5-9.99 years) and adolescence (10-17.99 years) were compared. Regression analyses testing for curvilinear relationships (entering the effects of linear, quadratic and cubic age in that order) were used to examine the association between height and age within each distinct period of childhood. A strong positive linear correlation was observed between age and height throughout childhood. The strength of the association decreased with age, 89%, 64%, and 60% of the variance in height in the pre-school, primary school and adolescent populations being explained by age alone (Appendix 3-Tables 5.3.58, 5.3.59 and 5.3.60).

A significant curvilinear relationship was observed between height and age within pre-school population; the inclusion of both age^2 and age^3 significantly increased the explained variance of height ($p<0.001$) (Table 5.3.58). The observed curvilinear relationship is accounted for by the relatively steep increase in height velocity during the first year of life which subsequently plateau's during the pre-school years. In comparison the relationship between height and age during middle childhood and adolescence is linear and gradual. The differences in the height velocity within each period of childhood are graphically illustrated in Figures 5.15-5.19. The differences in the predicted monthly height gains is also indicative of the rapid growth velocity that occurs during the pre-school years compared to the other two childhood periods. The estimated predicted monthly increases in height amongst pre-school children were 0.694 cm, nearly a third more than the 0.419 cm observed amongst primary school children and double the 0.359 cm estimates for the adolescent population (Appendix 3-Table 5.3.59-5.3.60).

No significant gender effect on height was observed after controlling for the respective age effects on height observed in each discrete period of childhood. Overall during infancy and middle childhood males were on average taller than females (Table 5.3.58 and 5.3.59). Females were predicted to be nearly a centimetre (0.869 cm) shorter than males of the same age during the pre-school years and (0.378 cm) shorter during middle childhood (Table 5.3.58 and 5.3.59). The converse was observed within the adolescent age group, the positive gender regression coefficient indicates that females were estimated to (0.329) cm taller than males of the same age (Table 5.3.60). The female superiority of height within the adolescent age group has been partially attributed to the apparent delayed maturation observed amongst adolescent males within Buhera. By extending the commonly associated period of adolescence (10-17.99 years) to encompass the additional three years of youth (18-21.99 years) the results of the comparative gender analyses are reversed. As males experience compensatory 'catch-up' growth during their youth they become significantly taller than their female counterparts ($p<0.001$) (Table 5.3.2).

5.3.3 Distribution of mean adult (≥18 years) height - gender and age differences:

The mean height of adult men and women in Buhera was 1.70 metres and 1.59 metres a highly significant difference ($p<0.001$) (Table 5.3.3). The least difference was observed amongst males and females aged 40-45 years and the largest difference amongst those aged between 60-65 years (Table 5.3.3).

The coefficients generated from the regression analyses which were used to assess the strength and direction of relationship between age and height within the male and female adult population suggest that there was an inverse linear relationship between height and age. This relationship was expected, it is generally assumed that with socio-economic development there is a corresponding secular increase in height; this phenomena is attributed to the environmental conditions which prevailed during the childhood of each respective cohort. Amongst the Buhera male adults the linear inverse association between height and age was weak; younger males (18-21.99 years) were only fractionally taller than their elderly (≥60 years) counterparts although the 5.7cm difference between the tallest and shortest age groups was statistically insignificant (Table 5.3.7). Interestingly, the pattern of declining mean height with each quintal was inconsistent. Although, on average men aged between 20-39 years were the tallest, the next tallest age group were men in their 60's who were slightly taller than males aged between 40-59 years (Table 5.3.8). This variable pattern in mean height by quintal within the male adult population is probably partially accounted for by the relatively small sample of men measured.

Within the female adult sample there was a highly significant inverse relationship between height and age (p=0.002). The regression analysis predicted -0.302 cm decrease with each quintal age class (Table 5.3.61). The Bonferroni *a posteriori* test indicated that within the female population there was significant heterogeneity in the mean height between elderly women aged ≥70 years who were the shortest and women in their 20's and 40's who were the tallest (Table 5.3.10).

5.3.4 Distribution of mean child (0-17.99 years) weight - gender and age differences: Figure 5.3 depicts mean weight during infancy, childhood, adolescence and extends into early adulthood (18-21.99 years). The weight pattern differs slightly from height. Male children on average were consistently heavier than females throughout infancy and the pre-school period. The gender difference in mean weight was highly significant amongst children aged between 12-23 months (p=0.003) and 36-47 months (p=0.001). The gender difference in mean weight within the 5-10 year age range were minimal and statistically insignificant, varying between (0.3-1.8kg). Throughout adolescence (11-18 years) females are predominantly more ponderous than males, the gender differences in mean weight are statistically significant at 11 years (p=0.048) and 15 years (p=0.023) (Appendix 3-Table 5.3.13).

If the weight and height distributions are viewed simultaneously it is evident that the gender differences in mean weight are generally determined by the gender differences in mean height. Each gender is heaviest during the periods when they are tallest; this corroborates the interaction and the major contribution of height to body mass. The parallel pattern between mean weight and height prevails throughout childhood with the exception of middle adolescence. Between the ages of 15-16 years females concurrently have a superior weight and inferior stature compared to males indicative of an increase in fat deposition. This difference can be attributed to fundamental changes in body composition known to occur during female adolescence.

It is evident from the above analyses that physiologically weight is highly related to age and height. It was necessary to control for both covariates before testing for the main effect of gender within the three distinct periods of childhood. Regression analyses were used to test for curvilinear effects between weight and age and analysis of covariance ANCOVA was used to control and adjust for the co-variants; these results are summarised in Appendix 3-Tables 5.3.58-5.3.60.

As expected there was a strong curvilinear relationship between weight and age during infancy and pre-school years; age and age^2 were highly significant ($p<0.001$) (Table 5.3.58). The positive age and negative age^2 coefficient suggests that weight gain is high during infancy and tends to plateau during the pre-school years. Regressing age and age^2 on weight suggests that 82% of the variance in pre-school weight was attributed to age alone. The addition of 'height' in the regression equation significantly improved the prediction of pre-school weight to 89%. After controlling for the curvilinear effect of age and covariance of height, the gender differences in pre-school weight remained highly significant ($p=0.002$). On average female pre-schoolers were 0.61 kg lighter than males of the same age (Table 5.3.58).

A robust highly significant positive linear relationship between weight and age was observed within middle childhood ($p<0.001$) (Table 5.3.59). No curvilinear relationship between weight and age was observed during this period of childhood. The constant linear accumulation of weight suggests that child growth during the 5-9 year age range followed a more stable homogenous pattern. The predicted coefficient was slightly lower than that observed amongst pre-school children; just over half (51%) the variance in weight was explained by age. The estimated monthly weight gain of 0.152 kg was also slightly less than the predicted gain for pre-school children. The inclusion of height within the regression model was highly significant ($p<0.001$) (Model 2, Table 5.3.59). In contrast, the addition of gender into the regression equation was statistically insignificant suggesting that there were relatively minor gender differences in mean weight within middle-childhood. The negative coefficient suggested that females on average weighed 0.221 kg less than males of the same age after controlling for age and height differences.

A significant curvilinear relationship was also observed between weight and age during adolescence (Table 5.3.60). It was estimated that 59% of the variance of weight amongst adolescents was explained by age alone. The positive age and negative age^2 insinuated that weight velocity was high during the first phase of pubescence and subsequently plateau's during the second phase of adolescence. The estimated monthly weight gain was 0.303 kg, approximately double that observed amongst the two younger age groups. The inclusion of height into the regression equation significantly improved the prediction of weight from 59.5% to 85% (p<0.001). The addition of gender within the regression model modestly increased the adjusted R square to 85.8%, The positive gender coefficient suggested that females were on average 1.449 kg heavier than boys of the same age after controlling for the curvilinear effect of age and covariance of height, the gender difference was highly significant (p<0.001) (Table 5.3.60). By further accounting for the interaction between age and sex, the final model predicted 86.2% of the variance in adolescent weight (Table 5.3.60 Model 2).

5.3.5 Distribution of mean adult (≥18 years) weight - gender and age differences:

The mean weight of adult males (58.9 ± 7.7kg) and females (59.8 ± 11.9kg) was similar, the gender differences were minimal and statistically insignificant. The relatively large standard deviation (SD) and coefficient of variance (CV) suggested that there was a high variability in body weight within the adult population. The variability in body weight was most pronounced amongst the women; the variance increased with age. The CV ranged between (9.3-15.8%) for adult males and (13.4-31.0%) for females. In recognition of unequal variances between the male and female samples and the large intra group variability both parametric and the non-parametric tests were used to compare the differences in weight.

Men on average were heavier than women until they reached 40 years although the differences in mean weight by quintal were statistically insignificant between the age of 22-40 years. Between the ages of 40-59.99 years the mean weight of females exceeds the mean weight of males until they were 60 years old. The observed gender differences in mean weight reached statistical significance amongst 40-45 year olds (p=0.019) and 50-55 year olds (p=0.037) (Table 5.3.13). On average males were heavier than females during old age; but not significantly so (Table 5.3.12).

Within the adult male population the pattern of weight during adulthood differed from the pattern of height. The regression curve estimation indicated that there was a weak inverse linear relationship between weight and age and no curvilinear relationship (Appendix 3-Table 5.3.61). The combination graph (Figure 5.5) simultaneously depicting mean male weight and height by quintal age classes clearly illustrates the interaction between weight and height. It is evident that male weight is largely determined by stature. With the exception of men aged between 30-40 years, weight mirrors the pattern of height, the tallest quintal being the heaviest. As expected male weight and height were highly positively correlated (p<0.001); regressing height on weight indicated that on average men weighed 0.622 kg more for each additional centimetre of height (Appendix 3-Table 5.3.61). Men were heaviest between 20-29.99 years reflecting their superior stature. Between 30-39.99 years mean weight was stable; this is followed by a sequential decline each quintal between 40-55 years, mirroring the progressive decrease in mean height. As men reach 60 years mean weight increases for the first five years; again this reflects their superior stature. An increase in weight during this age group may also be indicative of increased energy store due to both decreased BMR which occurs with age and also a decline in energy expenditure as their offspring take responsibility for the more labour intensive agricultural activities. There is a sharp decrease in mean weight after the age 65 years. After controlling for height the 7.3 kg difference between the lightest and heaviest age group within the male population was statistically insignificant (Table 5.3.18). When grouped by the three distinct periods of adulthood and after controlling for height, the difference in mean weight between young adult, middle-aged and elderly males remained statistically insignificant (Table 5.3.17).

In contrast to males, female weight followed a distinct upside down 'U'-shaped curvilinear pattern with age; the results of regression curve estimation reflect this by a highly significant quadratic age term (Appendix 3-Table 5.3.61). From young adulthood mean female mean weight rises 10 kg from 56.1 kg to peak at 66.1 kg between the ages of 40-44.99 years. Mean weight then declines only slightly during the next 10 years to 64.7 kg; thereafter there is a significant decrease. Women in their sixth decade on average weighed 56.8 kg whereas women ≥70 years were the lightest weighing on average 54.4 kg (Table 5.3.20). After controlling for the curvilinear effect of age, height remained a statistically significant determinant of female weight ($p<0.001$) (Appendix 3-Table 5.3.61). After controlling for height, a significant difference in the mean female weight by each age group remained ($p<0.001$) (Table 5.3.20). Bonferroni's *a posteriori* test indicated that there was significant heterogeneity between the mean weight of young adult females aged between 18-21 years and middle-aged women aged between 40-44 ($p=0.024$) and 50-54 years ($p=0.023$) (Table 5.3.20). Examining mean female weight by the three distinct periods of adulthood after controlling for height, a significant difference remained between the middle-aged who were the heaviest and young adults who were the lightest ($p=0.002$) (Table 5.3.19). No difference was observed between the mean weight of middle-aged and elderly women.

5.3.6 Distribution of mean mid-upper arm circumference (MUAC) of children aged 0-17.99 years - gender and age differences: Figure 5.4 and (Appendix 3- Table 5.3.25) illustrates the distribution of the mean male and female MUAC measure between 0-22 years. There was no significant gender difference or consistent pattern of gender dominance of mean MUAC within the pre-school population. The observed gender differences were small ranging between 0.3-0.6 cm. Amongst the primary school population females had a consistently superior mean MUAC compared to their male counterparts although the gender difference was minimal and statistically insignificant, varying between 0.0-0.3 cm.

After the age of 9 years there is a distinct steady increase in mean female MUAC to maturity; this increase is less marked in males. Throughout the first and middle phases of adolescence, 10-16 years, females continue to have a consistently superior mean MUAC measure compared to males. The gender difference was highly significant at 11 years (p=0.002) and 15 years (p<0.001). During the latter phase of adolescence as boys begin to experience puberty and become more muscular male mean MUAC supersedes females at 17 years; however the gender difference is statistically insignificant. Interestingly, as both sexes enter the pubertal growth spurt there is a noticeable reduction prior to the subsequent gain in mean MUAC for a short period.

The superior MUAC measure of adolescent females mirrors the pattern of their weight during this period. Theoretically since MUAC measures both muscle and sub-cutaneous fat a parallel increase in mean weight and MUAC within the female population during adolescence is indicative of the elevated pubertal and post-pubertal increase in fat body mass, a phenomena exhibited in black females world-wide. The reason for this distinctive sexual dimorphism in fat patterning expressed within the black African population is unknown.

In constrast to height and weight the strength of the relationship observed between MUAC and age was less pronounced. The respective adjusted R^2 values indicated only 11%, 18%, and 52% of the variance in pre-school, primary school adolescent MUAC was accounted for by age. Amongst the pre-school population a significant curvilinear relationship was observed between MUAC and age thus indicating that the MUAC increases significantly during infancy and plateau's during the pre-school years (Appendix 3-Table 5.3.58). In comparison, the increase in MUAC during the primary school years was more gradual and linear (Appendix 3-Table 5.3.59). However, amongst the adolescence the relationship between MUAC and age followed a more curvilinear pattern, the age^3 term was highly significant suggesting MUAC increased significantly at the beginning and end of puberty (Appendix 3-Table 5.3.60).

These results suggests that MUAC is only moderately affected by age within both the male and female population aged between 2-6 years. The predicted monthly increase in pre-school and primary school MUAC was minimal, (0.03 cm) (Appendix 3-Table 5.3.58-59). These results corroborate the recent recommendation by WHO (1995) that age adjusted MUAC values are unnecessary within the pre-school population aged 2-6 years. The lack of a significant gender differences in mean MUAC measures observed amongst children <10 years suggests it may also be possible to use a combined gender MUAC cut-off point to discriminate between the adequately nourished and malnourished in this community.

After accounting for linear and curvilinear effects of age, the gender coefficient was statistically insignificant within the pre-school population. The negative coefficient indicated that on average female MUAC was -0.195 cm smaller than males of the same age. During middle childhood the gender difference remained statistically insignificant but the converse situation was observed, a positive gender coefficient suggested that female MUAC was 0.2 cm larger than males of the same age. Within the adolescent population the female dominance prevailed, the gender difference of 1.1cm was highly significant ($p<0.001$) (Appendix 3-Table 5.3.60). These significant gender differences in the mean MUAC observed during adolescence suggest that it may be necessary to have gender specific cut-off points to identify the malnourished within this community.

5.3.7 Distribution and mean adult MUAC - gender and age differences: The overall mean male and female adult MUAC were 25.7± 2.3 cm and 28.6 ± 3.7 cm, respectively; the 2.7 cm gender difference in mean MUAC was highly significant ($p<0.001$) (Table 5.3.22). Examining the gender differences in mean MUAC by quintal it is evident that females have a superior measure compared to their male counterparts from 22 years onwards. The female bias in mean MUAC is highly significant between the ages of 30-59 years (Table 5.3.25).

There was minimal variation in mean MUAC amongst the adult male population; the mean MUAC measures ranged between 25.0-26.5cm. A weak statistically insignificant inverse linear relationship was observed between MUAC and age amongst male adults. The lowest mean MUAC measure was observed amongst men aged ≥70 years and the highest mean MUAC was observed amongst the 20-29.99 years age group. There was a highly significant positive correlation observed between MUAC and body weight observed amongst men (p<0.001); this was even more pronounced amongst women (p<0.001) (Appendix 3-Table 5.3.55). The combination graph (Figure 5.6) concurrently depicting mean MUAC and weight by quintal clearly illustrates how MUAC mirrors the pattern of body weight.

In contrast to the male population there was significant heterogeneity observed in the mean MUAC within the female adult population (p<0.001). The lowest mean MUAC value (26.5 cm) was observed amongst young adults whereas the highest, (30.9 cm) was seen amongst women in their 50's. Amongst middle-aged women MUAC was significantly positively correlated with age (p<0.001) whereas amongst elderly women (≥60 years) there was a weak inverse relationship observed between MUAC and age (Appendix 3-Tables 5.3.55, 5.3.57). These results suggest that there is a need to have gender and age specific cut-off points for MUAC to discriminate between the adequately nourished and malnourished within the adult population.

5.4 Assessment of the growth performance of Buhera children

The growth performance of children were assessed using HAZ, WHZ, and WAZ. The adequacy of adolescent weight for height was assessed using BMI-for-age reference data. Summary statistics, t-test and ANOVA results comparing HAZ, WHZ, WAZ and BMIZ by yearly age classes and by the three distinct periods of childhood are presented in (Table 5.4.1-5.4.11). Regression analyses presented in Appendix 3 were conducted to examine relationships between age and continous Z-scores for the pre-school (Table 5.4.12), primary school-aged (Table 5.4.13) and adolescent population (Table 5.4.14). The effects of linear, quadratic and cubic age were entered in the equation in that order. Contrary to the general assumption that age based anthropometric Z-scores are uncorrelated with age significant differences were observed. After controlling for the effect of age the gender differences were examined. The observed mean attained weight and height for each year group by gender was plotted against the NCHS median growth reference curve (Figures 5.21-5.22). The computed deviations from the reference population expressed as mean HAZ, WAZ, and WHZ for each yearly age group are illustrated in Figures 5.23 -5.24 by yearly age classes and gender.

5.4.1 Assessment of growth performance during infancy and the pre-school years:

It is evident from Figures 5.21-5.24 that infants are born with adequate weight and height for age and weight for their height and that anthropometric status progressively declines during the first two years of life, accelerating after the first six months of life. During the first six months of life the mean attained HAZ and WAZ of female infants is above the median of the NCHS growth reference for their age and the mean WHZ is on the median indicating that on average girls have a similar growth pattern to the NCHS reference. In contrast, male HAZ, WAZ, WHZ are slightly below the reference median indicating that boys are either born mildly short and underweight for their age and thin for their height or that their anthropometric status has subsequently deteriorated during the first few months of life. During the second half of the first year of life (6-11 months) there is a significant decline in both male and female WHZ and WAZ and slight decrease in mean HAZ.

During the second and third years of life the mean HAZ and WAZ for both males and females recover slightly from the weaning phase. Mean attained HAZ and WAZ is located between NCHS -1.5 and -2SD until the age of five indicating mild to moderate growth faltering. The decrease in WHZ continues albeit at a slightly slower rate. A significant curvilinear effect with age was observed for HAZ ($p<0.001$) and WAZ ($p<0.001$) (Table 5.4.12) during the pre-school years. The negative age term and positive quadratic and cubic age terms indicate that HAZ and WAZ deteriorate with age, then plateau's and subsequently recovers (Figures 5.31 and 5.37). After controlling for the linear, quadratic and cubic higher order effects of age, no gender differences in HAZ and WAZ were observed (Table 5.4.12). No age or gender effect was observed with WHZ within the pre-school population suggesting that the degree of thinness remains stable for both male and female under five's.

5.4.2 Growth performance during middle-childhood: Middle childhood (5-9 years) is sometimes referred to as the latent period since observed growth is usually steady and linear. As weight and height velocity rates decline substantially during middle childhood, the primary school-aged population in Buhera showed signs of a slight recovery in their growth performance. The moderate growth faltering observed during infancy and the pre-school years is seemingly arrested and gradual *catch-up* growth is exhibited. The mean HAZ, WAZ and WAZ are situated around -1SD for females and just below for males (Figures 5.21-5.24). There was no significant relationship observed between HAZ and WHZ with age or gender (Table 5.4.13). However, there was significant linear increase observed in WAZ with age (p=0.036). After controlling for the effect of age there was no gender difference (Table 5.4.13). The positive gender regression coefficients observed for HAZ, WAZ, WHZ suggest that girls have a slightly better growth and weight status for their age and height compared with boys of the same age during middle childhood.

5.4.3 Growth performance during adolescence: As the Buhera children enter the second accelerated phase of growth they rapidly exhibit a recurrence of an inferior height velocity relative to the NCHS growth reference data. Growth faltering becomes clearly evident as the overall mean HAZ declines from -1.0 observed in middle childhood to -1.4 in adolescence. The *catch-down* is progressive and particularly severe in males, so that the mean attained height of boys between 11-17 years is on, or just slightly above, -2SD. The mean stature of males falls slightly below -2SD at 16 years suggesting that on average, boys are moderately short for their age during the middle phase of adolescence. This substantial difference between the observed and expected attained heights may be primarily attributed to the variation in the timing of the Buhera male growth spurt relative to NCHS growth reference data.

By presenting the observed mean attained height of boys until 22 years it is evident that compared to the NCHS growth reference data adolescent male maturation in Buhera is delayed. There is clear evidence of a prolongation of the pubertal growth spurt relative to the NCHS population allowing male height to *'catch-up'* so that the final mean attained height of 22 year old males in Buhera is within normal limits, close to the NCHS median. Similarly, female adolescent height velocity is also lower during puberty compared to the NCHS reference data, although the restraint is not as severe as that observed amongst males. This suggests that maturation amongst females may not be as delayed as much as males. Like males, females in young adulthood, 18-21.99 years, also continue to grow exhibiting some *catch-up* during the second phase of puberty.

A highly significant curvilinear effect of age was observed with HAZ within the adolescent period; the significant positive age^2 term indicates that HAZ declines with age during the first phase of puberty and then subsequently increases with age during the second phase (Figure 5.33). After controlling for the curvilinear effect of age, the gender effect remained highly significant ($p<0.004$). The positive regression coefficients suggests that the growth of female adolescents was on average 0.304 HAZ greater than males of the same age (Table 5.4.14).

5.4.4 Mean height for age Z-scores (HAZ) - age and gender differences: The overall mean HAZ was negative for both males and females across all age groups in all survey rounds indicating that children in Buhera were generally short for their age. The regression analyses highlighted a significant relationship between age and HAZ. This section examines the main effect of age and gender on HAZ further by comparing the mean HAZ within each discrete period of childhood by yearly class intervals thereby highlighting more specifically the age when growth faltering becomes evident and the timing when gender differences emerge.

The overall mean HAZ's of the pre-school, primary school and adolescent populations were -1.3, -1.0 and -1.4, respectively. The results generated from the ANOVA for the whole child population suggest that there was significant heterogeneity in the mean HAZ's observed during the three discrete periods of childhood ($p<0.001$) (Table 5.4.2). The Bonferroni *a posteriori* test indicated that children in middle childhood had a significantly superior mean HAZ compared to adolescents, but, there were no significant differences observed between the pre-school population and the two older age groups. This pattern was observed within the male population but differed slightly for females. Within the female child population girls in middle childhood had a significantly superior mean HAZ compared with their younger and older counterparts, but there was no significant difference in the mean HAZ between the pre-school and adolescent age groups. These results suggests that the Buhera child population are significantly more likely to be short for their age during the two phases of rapid growth velocity compared to middle childhood when growth is more steady.

When disaggregated further by yearly age classes, growth faltering becomes evident in the second year of life onwards. Within the pre-school population the Bonferroni *a posteriori* test indicated that there was significant heterogeneity between the relatively higher mean HAZ observed amongst infants compared to children within each yearly age cohort in the pre-school years (1-4 years) (Table 5.4.4). Within middle childhood there was no significant statistical difference observed in the mean HAZ by yearly age class. Whereas within the adolescent population the Bonferroni *a posteriori* test indicated that there was significant heterogeneity in the mean HAZ between children aged 11 and those aged around 12 years (Table 5.4.4).

The overall mean HAZ for males was lower than females in each discrete period of childhood, suggesting that boys were shorter for their age than girls from infancy, through childhood into adolescence although the difference only reached statistical significance during pubescence ($p=0.002$) (Table 5.4.1). When disaggregated into yearly age classes no significant gender difference was observed in mean HAZ during the pre-school years or middle childhood with the exception of seven year olds. Girls aged 7 years showed significant better growth performance compared with their male counterparts (p=0.006) (Table 5.4.3). The gender disparity in growth performance was most pronounced during adolescence when a highly significant age group (p=0.028), gender (p=0.005) and age sex interaction (p=0.001) was observed (Table 5.4.4). The age sex interaction is probably largely explained by the timing of pubescence. At 10 years, as girls enter adolescence they have an inferior HAZ although the difference is statistically insignificant. After the females have experienced peak height velocity (PHV) at around 15-17 years they are significantly taller for their age than their male counterparts who, due to delayed maturity, have a notably inferior HAZ (Table 5.4.4). These results suggest that overall there is no significant gender difference in the growth performance of Buhera children until adolescence. During adolescence male children are significantly shorter for their age than their female counterparts; this disparity is attributed to the delayed male maturation rather than an overt difference in nutritional status.

5.4.5 Mean weight for height Z-scores (WHZ) - age and gender differences: Due to the problems associated with the interpretation of WH during adolescence WH is only assessed for children <10 years. The adequacy of adolescent WH was assessed using BMI Z-scores for age (Section 5.5). The overall mean WHZ for the whole child population <10 years was negative, -0.5 for the whole child sample (<10 years), suggesting that some children within the study population were thin for their height. The regression analyses (Appendix 3-Tables 5.4.12 and 5.4.13) suggest there was no significant age effect with WHZ within the pre-school or primary school populations However, when examining the child population as a whole (<10 years) a highly significant inverse linear relationship was observed suggesting that as children got older they were thinner for their height.

Independent t-test, used to compare the mean WHZ of pre-school and primary school children, verified that primary school children had a significantly lower WHZ than pre-school children (p=0.008) (Table 5.4.5). Within the pre-school and primary school populations no significant difference was observed in the mean WHZ by yearly cohorts. The relatively higher SD, CV and large range in WHZ values observed within the pre-school population suggests that there is notable heterogeneity within this age group compared to the primary school population. This is clearly evident from the Figures 5.41 and 5.42. On average male pre-school children had a higher mean WHZ compared to females within the pre-school population; the reverse pattern was observed amongst the primary school population. In each case the gender differences were statistically insignificant.

5.4.6 Mean weight for age Z-scores (WAZ) - age and gender differences: Weight for age (WA) reflects body mass relative to chronological age. Due to the problems associated with chronological age and puberty, WA is generally not used to assess underweight within the adolescent age group; hence the data presented in this section pertains to children <10 years. The overall mean WA for the child population was negative (-1.1) suggesting that the child population in Buhera were on average mildly underweight for their age. No significant age group or gender differences were observed when comparing the mean WAZ of pre-school and primary school children (Table 5.4.7). However, throughout the study boys had a similar or lower WAZ than girls indicating that on average male children were more underweight for their age than females.

Within the two discrete periods of childhood the insignificant gender differences prevailed but the effect of age became more evident. A significant curvilinear effect was observed between age and WAZ within the pre-school population; the negative age coefficient combined with a positive age^3 term suggests that WAZ declines significantly with age, then plateau's and then subsequently recovers slightly. This curvilinear pattern is clearly illustrated in Figure 5.35. The results of the regression equation suggest that WAZ declines -0.191 with each month of age (Table 5.4.12). The one-way ANOVA comparing mean WAZ by each yearly age class suggest that there was significant heterogeneity in the mean WAZ (Table 5.4.8). The Games-Howell *a posteriori* test indicated that the mean WAZ of infants aged <1 year was significantly higher than children in the pre-school years. This result suggests that underweight becomes significantly more evident after the first year of life. After controlling for age group differences and the higher order age effects, the effect of gender was statistically insignificant within the pre-school population (Table 5.4.12).

Compared to the pre-school years the reverse pattern was observed during middle-childhood; a significant inverse linear association was observed between WAZ and age (p=0.036) (Table 5.4.13). The regression equation estimated that WAZ decreased 0.005 with each year of life between 5-9 years suggesting that as the children got older their WA steadily declined. After controlling for linear effect of age, the gender effect remained just significant; the positive coefficient indicates that female WAZ were 0.164 higher than their male counterparts of the same age (Table 5.4.13). Female primary school children were consistently heavier than their male counterparts throughout the study.

5.4.7 Interpretation of the weight for age (WA) indicator: To verify the assumption that WA deficit in Buhera was more attributed to growth faltering than thinness the WA indicator was correlated with the HA and WH indicators. The results of linear bivariate correlation analyses verified that there was a stronger linear relationship observed between WA and HA (r=0.712; p<0.001) compared to the association between WA and WH (r=0.620; p<0.001) (statistics not tabulated). These results suggests that WA and HA share nearly three quarters of the same information compared to WA and WH which share two thirds of the same information. This suggests that weight deficit is more attributed to retarded linear growth rather than the lack of weight *per se*.

5.5 Diagnosis of the child nutritional status within Buhera

The mean anthropometric indices indicate that the Buhera children in the survey are on average the correct weight for their height but short and underweight for their age. However, using the mean obscures the distribution of malnourishment within the sample. By considering the range and the proportion below specified cut-off points it is possible to begin to assess the magnitude of malnutrition within the child population. Two classification systems were used. The first was a dichotomous categorisation using -2 SD to differentiate between adequate nourishment and malnourishment. The second classification system categorised anthropometric status into varying degrees of nutritional status from adequate nourishment to severe malnourishment based on the observed Z-score value: adequately nourished (≤-1 SD), mildly (-1SD to -2SD), moderately (-2SD to -3SD) or severely (>-3SD) malnourished. Chi square analyses were used to examine the association between gender and the degree of stunting, thinness, wasting and underweight within each age group by survey round (Table 5.5.1).

5.5.1 Prevalence of shortness and stunting: Low HA is described as 'shortness', shortness can reflect either normal variation or a pathological process. In the prevailing environmental conditions of study area where the prevalence of low HA is relatively high, it is assumed that the majority of children exhibiting low HA were pathologically short i.e. stunted. Stunting was diagnosed as HAZ <-2 SD, the overall prevalence rate of stunting amongst the child population (0-17.99 years) was 23.9% in Mar-95 suggesting that one in four children was stunted. Applying the WHO (1995) proposed classification of world-wide prevalence ranges for low HA, this situation was classified as medium to high risk. The rates of stunting varied by gender and age; the differences in prevalence by age group were statistically significant (Table 5.1.1).

5.5.2 Prevalence of shortness and stunting - low Height for age (HAZ) by gender: For the whole population the proportion of males (26.3%) classified as stunted exceeded that of females (21.6%), although the gender difference was statistically insignificant. Overall males were 1.3 (95% CI 1.0-1.7) times more at risk of being stunted compared to females. This pattern of higher male prevalence rates of stunting prevailed within all three discrete periods of childhood. During pre-school, middle childhood and adolescent periods males were 1.1 (95% CI 0.6-1.8), 1.6 (95% CI 0.9-2.8) and 1.4 (95% CI 0.9-2.1) times more at risk of being stunted compared to their female counterparts (Table 5.5.1). In each case the gender differences were statistically insignificant. The gender difference in prevalence rates was particularly small within pre-school population (0.9%); a somewhat larger disparity was observed during middle childhood (6.2%) and adolescence (6.0%).

5.5.3 Prevalence of shortness and stunting - low Height for age (HAZ) by age: A highly significant association was observed between stunting and age (*p*=0.001) (Table 5.5.2) There was no secular trend with age; the prevalence of stunting increased significantly during periods of elevated growth velocity namely the pre-school years and adolescence compared to middle childhood when growth was generally more steady (Figure 5.41 and 5.42). Pre-school children and adolescents were 2-3 times more at risk of stunting compared to primary school children (Table 5.5.2). Applying the current WHO (1995) diagnostic classification system the prevalence rates of stunting amongst the pre-school (27.9%) and adolescent (26.6%) population were classified as a *moderate to high risk* situation whereas the prevalence rate amongst primary school children (17.0%) was considered a *low to moderate risk.*

Within age group analysis suggested that there was a significant difference in the proportion of children diagnosed as stunted within each yearly age class in the pre-school population (*p*=0.007) (Table 5.5.3). Approximately, one in ten (10.9%) infants (<12 months) were diagnosed as stunted compared to one in three (32.1%) one year olds, one in four 2 and 3 year olds and 40.3% of four year olds (Table 5.5.3). Figures 5.41 and 5.42 clearly illustrate the gender disparity in the prevalence of stunting within the pre-school population. The gender difference was particularly evident amongst infants (<1 year). The prevalence of male stunting was 4.5 times higher than that observed amongst females. Male infants were 5.2 (95% CI 0.5-46.1) times more likely to be stunted than girls.

There was no significant difference in the prevalence of stunting between each year group within the primary school population (Table 5.5.4). Within the adolescent age group there was a significant difference between each yearly age class for males

($p<0.001$) only (Table 5.5.5). As males entered adolescence at age 10 one in ten boys were diagnosed as stunted, by the age of 12 years this increased to one in five (21.2%), by 14 and 15 years old due to the late maturation one in two were categorised as stunted. In comparison, with the female adolescent age group the variation in the prevalence of stunting by yearly age classes was less pronounced. The levels of stunting peaked at 39.5% amongst 12 year olds. After the girls had experienced their peak height velocity (PHV) around 15 years the level of stunting decreased to 17.9% (Table 5.5.5). Figures 5.41 and 5.42 clearly illustrate the interaction between gender the onset puberty and subsequent increase in stunting.

5.5.4 An evaluation of the impact of the disjunction in the NCHS growth reference data on pre-school stunting estimates: Overall pre-school children were most at-risk of stunting; this result was largely unexpected. Within chronically food insecure situations it is common to observe relatively higher prevalences of stunting amongst older children, a phenomena directly attributed to the duration of the retardation process. The relatively higher prevalence rate of stunting and the significant variation in the incidence rate of stunting within the pre-school population has been attributed to the disjunction between the FELS and NCHS growth reference data-sets which approximates to 0.5 SD or 1.8 cm (WHO, 1995). This disjunction can have a negative impact on the proportion of infants diagnosed as stunted between 18-23 months.

Mean HAZ were computed for 3-monthly age intervals, to identify the exact timing of the decline and sudden improvement of HAZ's in the Buhera study. It is evident that there is a marked difference between the estimated height status immediately before and after 24 months of age (Figure 5.43). This pattern prevailed for both the male and female pre-school children. Figure 5.44 presents the percentage change in stunting generated by sequentially subtracting the previous 3-monthly age class stunting rate. Over half (54.5%) the children aged between 21-23 months were classified as stunted (<-2 HAZ). In comparison, the prevalence of stunting was less than one in five (18.2%) amongst children who were on average 3 months older (24-27 months). The 36.3% decline in the prevalence rate of stunting over the 24 month disjunction is clearly depicted. This substantially reduction in the prevalence of stunting is partially attributed to the use of the FELS and NCHS growth reference data rather than an extraordinary difference in linear growth.

The absolute difference in mean HAZ and prevalence rates of stunting generated from the FELS and NCHS growth reference data were computed for the children aged between 24-36 months, the age range for which the two growth reference data-sets overlap. A paired *t*-test was used compare the two HAZ. The mean FELS and NCHS HAZ for male children were -1.35 and -1.89, respectively, the 0.54 SD difference was highly significant (t=17.193, df=22, p<0.001). Similarly, the female HAZ generated from FELS growth reference (HAZ -1.96) was significantly lower than that computed using the NCHS growth reference data (HAZ -1.46) (t=15.848, df=24, p<0.001). The prevalence of stunting amongst male and female children using the FELS growth reference data was 43.4% and 48.0%, respectively. These prevalence rates was approximately 1.7 times higher than those generated for males (26.1%) and females (28.0%) using the NCHS growth reference data. This result suggests that the FELS growth reference data over-estimates the prevalence of stunting amongst three year old boys and girls by 17.4% and 20%, respectively. Assuming that the FELS growth reference systematically over-estimates the prevalence of stunting by 20% then the prevalence rates amongst children aged <24 months are similar to those aged ≥ 24 months of age. Figure 5.45 illustrates how the whole distribution of the HAZ was affected, there was a general negative shift in the linear growth estimates. Using the FELS growth reference data the proportion of children aged 24-36 months considered to have adequate HA was 22.9% lower. Mild, moderate and severe stunting prevalence rates were 4.2%, 10.5% and 8.5%, higher than the estimates generated from the NCHS growth reference data.

5.5.5 The extent and severity of stunting within child population: The child sample (n=1,092) was disaggregated into four categories pertaining to attained height status: adequate height for age, mild, moderate and severe stunting; the proportion of the whole child population within each category was 40.2%, 35.9%, 18.9% and 5.0%, respectively. From these results it is evident that the majority of the children classified as stunted were moderately rather than severely short for their age and of those diagnosed as not stunted, approximately a third were diagnosed as mildly short for their age. There was a significant association between gender and the degrees of shortness for the whole child sample (p=0.013) (Table 5.5.6). Further analysis suggested that female children were less likely to be mild, moderate or severely short for their age in all three phases of childhood. However, significant gender differences in prevalence rates were confined to adolescence (p=0.010) (Table 5.5.7, Figure 5.47).

For the whole child sample there was a significant difference in the proportion of children classified of adequate height-for-age, mild, moderately and severely short for age (p<0.001) (Table 5.5.8). As Figure 5.46 clearly illustrates pre-school children are less likely to be mildly short and more likely to moderately short for their age. Whereas children of primary school age are more likely to have an adequate height for their age and less likely to be categorised as mild, moderate or severely short. Adolescents were less likely to be of adequate height for their age but more likely to be mild or moderately short for their age.

5.5.6 Characteristics of stunted children by gender and age group: Stunted pre-school children were significantly older than those diagnosed with adequate HA (p=0.002). After controlling for linear and higher order effects of age stunted pre-schoolers were not only shorter but also had a significantly lower weight (p<0.001), MUAC (p=0.003) and WAZ (p<0.001) compared with non-stunted pre-school children, suggesting that stunted children not only show a marked growth retardation but also an significant degree of underweight. In contrast, the mean BMI of stunted pre-school children was significantly higher than their taller counterparts (p=0.037) as was the mean BMIZ-for-age (p=0.017). Whereas, the mean WHZ of stunted children was also higher than non-stunted children but did not reach statistical significance. These results suggests that although stunted pre-school children were underweight their body mass or weight relative to height was proportional.

A similar pattern prevailed amongst primary school-aged population but the differences were less pronounced. Stunted primary school-aged children were slightly older but the age difference was statistically insignificant. Stunted primary school-aged children were on average 3.3 kg lighter (p<0.0.01) and also possessed a significantly lower MUAC measure (p<0.001). The difference in mean BMI, BMIZ-for-age and WHZ between stunted and non-stunted primary school population were minimal and statistically insignificant. In contrast, the mean WAZ was significantly lower for stunted primary school-aged children indicating that they were underweight (Table 5.5.10). The interaction between the adequacy of weight for height and linear growth became most pronounced during puberty, stunted adolescents were significantly thinner than their taller counterparts (p<0.001) (Table 5.5.11).

5.5.7 Prevalence of low Weight for height (WHZ), thinness or wasting: The prevalence of wasting (<-2 SD WH) within the child population (<10 years) in Mar-95 was 5%, a situation categorised as low (WHO, 1995).

5.5.8 Prevalence of low Weight for height (WH), thinness or wasting by gender: Overall, a slightly higher proportion of female children (<10 years) were diagnosed as wasted (-2SD WHZ) compared to males; this trend prevailed within the pre-school and primary school populations. The gender differences were statistically insignificant in both age groups.

5.5.9 Prevalence of low Weight for height (WHZ) or wasting by age: The prevalence of wasting decreased with age; although the rate (6.4%) observed amongst the pre-school population was approximately double the rate (3.8%) observed within the primary school population, the difference was statistically insignificant (Table 5.5.13) The association between wasting and age within the pre-school and primary school populations were also statistically insignificant. However, with the pre-school population there was significant inverse linear association between wasting and age (p=0.015). Approximately one in ten children aged <24 months were wasted compared to 4.8% of 2 years olds, 3.3% of 3 years olds and 2.8% of 4 year olds (Table 5.5.14). Within the primary school population there was no obvious trend between wasting prevalence rates and age. These results suggest that the overall the risk of wasting decreased with age (Table 5.5.14).

5.5.10 The extent and severity of wasting: Examining the degree of wasting within the child population suggested that of children diagnosed as wasted, the majority were moderately wasted; only 0.5% were diagnosed as severely wasted (<-3 SD WHZ) (Table 5.5.15). However, amongst the children diagnosed as not-wasted, one in four (25.4%) were classified as mildly wasted (-1.01 to -2.00). There was no association between gender or age and the degree of wasting (Tables 5.5.15 and 5.5.16). The relatively high level of mild wasting suggests that the relatively low prevalence rate of wasting should be interpreted cautiously. It has been argued that since wasting can occur rapidly the -2 SD cut-off point is too low and it may be more appropriate to increase the cut-off point to <-1.5 SD as a preventative measure. The prevalence of wasting amongst the pre-school and primary school population using WHZ <-1.5 SD cut-off point was 12.7% and 12.8%, respectively.

5.5.11 Prevalence of low Weight-for-age (WA) or underweight: The prevalence rates of low WA or underweight (-2 WAZ) mirrored the pattern of stunting. Overall, one in six children (15.5%) aged <10 years were diagnosed as underweight. The overall gender difference in the prevalence rate of underweight amongst children aged <10 year was minimal and statistically insignificant. Pre-school females were at slightly higher risk being 1.4 (95% CI 0.8-2.7) times more likely to be diagnosed underweight compared to their male counterparts. The reverse situation was observed amongst the primary school-aged population. In middle childhood one in ten girls compared to one in six boys were classified as underweight. The association between the prevalence of underweight and gender was statistically insignificant in both age groups.

5.5.12 Extent and severity of underweight: There was no association between gender and the degree of underweight amongst the pre-school or within the primary school population. As stated earlier, although WAZ is the most commonly used anthropometric indicator its composite nature makes it difficult to interpret. It is evident that underweight children are not a homogenous group; they can be undersize but relatively proportional or they can be underweight and wasted. The unspecific nature of WA is one of its main limitations and has spurred researchers to develop alternative classification systems which distinguish between 'acute' and 'chronic' forms of malnutrition. The most commonly cited is Waterlow's classification system (Waterlow, 1972). Waterlow's classification simultaneously incorporates the HA and WH indices and classifies the population into four categories: normal, stunted only, wasted only and wasted and stunted, thereby identifying the most vulnerable and those in immediate need in terms of public health priorities.

5.5.13 Waterlow's classification: The child population was re-categorised into Waterlow's four group classification system using the following series of cut-off points: normal (≥-2 HAZ and ≥-2 WHZ), wasted only (≥-2 HAZ and <-2 WHZ) stunted only (<-2 HAZ and ≥-2 WHZ) and wasted and stunted (<-2 HAZ and <-2 WHZ). Applying Waterlow's classification to the whole child population (<10 years) only 0.6% were simultaneously classified stunted and wasted. Less than one in twenty (4.3%) were classified as wasted only, one in four (21.4%) were categorised as stunted only and nearly three-quarters (73.6%) were considered 'normal'. There was no association between Waterlow's classification of nutritional status and gender (Table 5.5.22). In contrast, there was a significant association with age groups (p=0.002) (Table 5.5.23). The pre-school population was significantly more at-risk of all forms of malnourishment compared with the primary school population, the prevalence rate of wasting and stunting were 1.2% and 9.6%, higher amongst the younger age group.

Within the pre-school population the association between Waterlow's classification of malnourishment and gender was insignificant whereas the association with yearly age classes was statistically significant (p=0.018) (Table 5.5.25). By category, significantly more infants and three year olds than expected were classified as 'normal'; in contrast less than expected 2 and 4 year olds were considered 'normal'. Wasting only prevalences were higher than expected amongst children aged <24 months and lower than expected amongst 4 year olds whereas the reverse situation was observed for stunting only incidence rates with the younger age groups exhibiting the least stunting only and their older counterparts exhibiting the highest. Amongst this age group children aged 12-23 months exhibited the highest rate (3.8%) of concurrent wasting and stunting (Table 5.5.25).

Overall the association between Waterlow's classification of malnutrition and gender or age was statistically insignificant for the primary school population. Within the primary school population slightly more female children were considered 'normal' and slightly less than expected were stunted whereas the reverse situation was exhibited amongst males (Table 5.5.26). By yearly age classes, 7 year olds were the least likely to be malnourished, 87.7% were considered 'normal'. The highest rate (7.8%) of wasting only was observed amongst 5 year olds, the highest rate (20.0%) of stunting only was measured amongst the 8 and 9 year olds. No children in middle childhood were concurrently classified as stunted and wasted (Table 5.5.27). From the above results children aged 12-23 months should be given first priority since they exhibited the highest level of concurrent wasting and stunting.

Considering the observed distribution of HAZ and WHZ the application of -2SD cut-off point within the Waterlow's classification provides limited insight into the spectrum of malnutrition in a chronic situation like Buhera. Waterlow's classification was modified to incorporate three levels of malnutrition, 'adequate', 'mild' and 'moderate or severe'. Using this modified approach: 0.6% continued to be simultaneously classified stunted and wasted, a sixth (15.2%) were classified as wasted only with no evidence of growth retardation; of these 12.9% were mildly wasted and 2.3% were categorised as moderate to severely wasted. The majority 40.1% of the children were categorised as stunted but not wasted; of these 23.7% were mildly short for their age and 16.4% were moderate to severely stunted. Incorporating mild wasting and stunting subsequently decreased the proportion of children categorised as 'adequately nourished' (with no degree of stunting or wasting) to less than a third (29.5%).

The distribution of Waterlow's classification followed a similar pattern within the pre-school and primary school populations. Amongst the pre-school age group the prevalence of children simultaneously classified as moderate to severely stunted and wasted was 1.4% whereas within the primary school population no child was concurrently classified as moderately to severely wasted and stunted. Nearly half (46.7%) the pre-school population was stunted not wasted compared to a third (34.7%) of the primary school population. Only one in five (24.6%) pre-school children were classified as adequately nourished (not stunted or wasted) whereas one in three (33.5%) primary school children were considered adequately nourished. On the basis of the above results pre-school children aged around 12-23 months remain the most nutritionally at-risk.

5.6 The use of Body Mass Index (BMI) to diagnose nutritional status throughout the life-span

Given the various limitations associated with diagnosing the adequacy of adolescent weight for height using the NCHS growth reference data, WHO (1995) recommends BMI-for-age as the best indicator for use in adolescence. Cole (1985) advocates using the index W/H^2 to monitor nutritional status throughout the life-span. BMI is an accepted measure of CED and obesity in adults due to its virtual independence from height and high correlation with weight and body fat (FAO, 1994). However, these linear associations are not as evident in prepubescent children and are somewhat biased by stature. This was observed in Buhera child population. The correlation matrices (Appendix 3-Table 5.3.46-49) summarises the direction and strength of the bivariate relationship between height and weight during childhood using three different power indices (W/H^P: 1.5, 2 and 3).

W/H^2 was the least correlated with height within the pre-school and primary school population; however the strength of the correlation with weight relative to the other power indices was also low too. W/H^2 was highly correlated with adolescent height. By contrast the W/H^3 also known as the Ponderal index was inversely insignificantly correlated with height amongst male adolescents. However, W/H^3 was also shown to have a substantially lower correlation with body weight than Quételet's index (W/H^2). The comparative analyses of bivariate correlations between the three power type indices, height and weight for this child population provide inconsistent results. With this caveat in mind the most pragmatic solution was to use WH^2 since overall it was least correlated with height, highly correlated with weight and probably its primary advantage over the other indices is that it has been the main index of choice internationally for the past century.

5.6.1 Distribution of male and female BMI throughout the life-span: Figure 5.48 contrasts male and female BMI throughout the life-span providing a comparison of fatness through the life-cycle. The mean BMI of pre-school and primary school males in Buhera was consistently higher than females until the age of 6 years, between 6-7 years the mean BMI of females is marginally greater and from 7-10 years males have a slightly larger mean BMI. There were no significant gender differences in mean BMI until the onset of puberty. At 13 years the male and female BMI curves cross over; during the first and middle phase of adolescence females aged 11, 15 and 16 years had a significantly larger BMI measure compared to males of the same age (Table 5.3.36). At 17 years boys have a slightly larger mean BMI measure probably reflecting an increase in muscularity. When examined by discrete childhood periods male pre-school children had a significantly larger mean BMI than their female counterparts (p=0.023) (Table 5.3.37), whereas, amongst the adolescent population the reverse situation was observed with adolescent females having a significantly larger mean BMI compared males (p=0.006) (Table 5.3.34).

From 18 years onwards the mean BMI of females was consistently higher than males throughout adulthood, the gender difference in mean BMI within each quintal age class was highly significant until the age of 60 years (Table 5.3.36). Female adults continued to have a higher mean BMI throughout old-age but the gender difference was not significant until ≥75 years (Table 5.3.36). This consistent pattern of a notably higher female BMI throughout adolescence, early adulthood, middle-age prevailing into old-age is indicative of their greater energy stores and hence a better nutritional status compared to their male counterparts.

5.6.2 Distribution of mean BMI by age - Evidence of 'adiposity rebound': When examined by yearly age classes it is evident that the changes in mean BMI during infancy and the pre-school years are dramatic in the early growth phase. A positive curvilinear relationship between BMI and age was observed within the pre-school population suggesting that there was significant increase in BMI during infancy which plateau's during the pre-school year's (Table 5.4.12). Mean BMI increases during infancy peaking between 24-36 months, from 3 years onwards there is a gradually decline in mean BMI until the children reach 8 years. There is a significant difference in the mean BMI by yearly age classes within the pre-school years. The Bonferroni *posterior* test indicated that both male and female children aged 2-3 years olds had a significantly higher mean BMI compared with 4 year olds (Table 5.3.41). The difference in mean BMI by yearly age classes within the primary school population were statistically insignificant for both males and females (Table 5.3.42).

From 8 years onwards in the Buhera child population there is a subsequent gradual rise in mean BMI observed amongst boys and girls. This incline of the BMI curve has been termed 'adiposity rebound'. The timing of the 'adiposity rebound' has been related to and is diagnostic of adult adiposity level. It has been postulated that earlier the rebound (< 3 years), the higher the subsequent adiposity and risk of adult obesity (Rolland-Cachera, *et al.*, 1984, 1987). Figure 5.49 compares the gender specific BMI curves generated for the Buhera population with those constructed and published for the French (Rolland-Cachera, 1991), Italian (Luciano, 1997) and Chinese (Leung, *et al.*, 1998) population. It is evident that for all populations there is a rapid increase in BMI during the first 6 months of infancy which peaks between 6-12 months then there is a subsequent decrease to a trough at approximately 6 years in the European and Chinese populations before another rise towards adulthood. It is apparent from comparing the BMI curves created for Buhera population with those from France, Italy, the UK and China that during the pre-school years the median BMI of the Buhera population is similar to the European and Chinese population. This similarity in BMI curves until the age of six years across different environments is attributed to low fat body mass at this age whatever the nutritional condition of the population. At around six years the BMI curves start to deviate due to the subsequent two year delay in the 'adiposity rebound' exhibited by both male and female children within the Buhera population. The median male and female BMI for Buhera children is significantly lower throughout middle childhood and the first two phases of adolescence compared with the median BMI for European and Chinese populations. Towards the end of adolescence the median BMI of Buhera population is similar to the median BMI of French, Italian, and English and slightly above the Chinese population. The interpretation and possible implications of the delayed adiposity rebound are discussed in Chapter 8.

Figure 5.48 compares the mean male and female BMI for the Buhera and French population throughout the life-span. It is evident that as both population's enter adulthood there is continual rise in mean BMI during middle-age. Since, lean body mass (LBM) declines progressively with age during adult life the increases in BMI during middle-age are considered to be a reflection of increased fat body mass (FBM). A weak inverse correlation was observed between BMI and age amongst middle-aged males in Buhera (Appendix 3-Table 5.3.54). The Buhera male BMI curve substantially deviates from the French male and female and Buhera female populations', this is indicative of comparatively lower levels of fat body mass. Whereas the moderate positive correlation between BMI and age observed amongst middle-aged women in Buhera (Table 5.3.55) and their relatively higher BMI compared with both the French male and female population provides a contextual illustration of the high level of fatness observed amongst women in Buhera.

5.6.3 Relationship between BMI-for-age Z-scores (BMIZ) and other anthropometric measures and indicators for child population: To control for the variation in BMI and age throughout childhood the child BMI values were compared with median BMI reference values for corresponding age in months from the NHANES III (CDC, 2000) and expressed as Z-scores. Bivariate correlation analysis was used to examine the relationship between BMI-for-age Z-scores (BMIZ) and the three most commonly used anthropometric measures: weight, height and MUAC and indicators: HAZ, WHZ, and WAZ. The correlation matrices for each discrete childhood period are presented in (Appendix 3-Tables 5.3.46, 5.4.47, 5.4.49, 5.3.50).

For the pre-school population BMIZ was more strongly correlated with WHZ (r=0.970, p<0.01) than WAZ (r=0.613, p<0.01). When comparing the two correlation coefficients using t-test there is a highly significant difference between the two coefficients (t=16.030, p<0.01). In contrast, there was a weak inverse relationship observed between BMIZ and HAZ amongst pre-school children (r=-0.171, p<0.05) suggesting shorter children had a slightly higher BMIZ. Regression analyses were used to examine the relationship between BMIZ and age. Amongst pre-school population aged between 24-59 months there was a significant linear effect (p=0.030). The negative regression coefficient suggests that as pre-school children progressively get older they also get thinner; the predicted monthly decline in the BMIZ was -0.02. After controlling for the linear effect of age the gender differences were statistically insignificant. The negative gender regression coefficient, suggests that the female BMIZ was lower than males of the same age (Table 5.4.12).

Amongst the primary school aged population the results generated from the bivariate correlation analysis between WHZ and BMIZ and WAZ and BMIZ followed a similar pattern to pre-school children. All the weight based indicators were positively correlated, and the correlation with WHZ was also significantly stronger than WAZ (t=16.04, p<0.01). No correlation with HAZ and BMIZ was observed in middle childhood (Table 5.3.5). The regression estimates revealed no linear or curvilinear effects with age, or gender effect with BMIZ (Table 5.4.13). The respective negative regression coefficients associated with age and sex suggests that the pattern observed within the pre-school population prevails during middle-childhood; BMIZ continues to decrease with age and females have a lower BMIZ compared to male children of the same age.

Within the adolescent population a highly significant curvilinear relationship was observed between BMIZ and age this is clearly shown in Figure 5.36 the BMIZ initially declines with the onset of puberty particularly amongst males and then during the second phase of pubescence there is a significant incline in BMIZ. This pattern suggests that as adolescents enter puberty they are relatively leaner for their height compared to the period ensuing peak height velocity (PHV) which is subsequently associated with an increase in BMIZ indicative of increasing fat body mass relative to growth reference population. Figure 5.36 clearly illustrates the significant sexual dimorphism that occurs during adolescence. As children enter adolescence, at aged ten females have a slightly lower BMIZ and with the onset of the first phase of pubescence at around 11 years the girls BMIZ curve supersedes the boys BMIZ and remains higher throughout adolescence. The divergence of BMIZ curves are attributed to the gender differences in the timing of weight and height growth and variations in body composition which takes place during pubertal maturation; the curves show typical sexual dimorphism as fatness increases in females and tends to decrease in males. A highly significant positive relationship was observed between BMIZ and HAZ amongst both male and female adolescents suggesting that the adequacy of weight for height is strongly associated with the adequacy of height for age during adolescence.

5.6.4 Diagnosis of child nutritional status using BMI: The use of BMI-for-age to diagnose child nutritional status is an area of current debate. WHO (1995) presently recommend using BMI-for-age as the most appropriate anthropometric indicator for use in adolescence. WHO advocate using the 5th and 95th percentile as cut-off points to diagnose underweight and overweight. The application of the 5th percentile cut-off point to diagnose thinness in the Buhera child population produced considerably higher estimates of malnourishment within all three discrete periods of childhood (pre-school, middle childhood and adolescence) relative to other age groups (Figure 5.50) and other anthropometric indices (Figure 5.50). The estimated prevalence of thinness using the 5th percentile was approximately three times the estimated prevalence of wasting (<-2SD WHZ) in the pre-school population and five times the estimated prevalence of wasting in the primary school population (Table 5.5.36-5.5.41). The sensitivity and specificity values associated with 5th percentile BMI for age used to predict child wasting amongst pre-school population were high, 100% and 91.7%, respectively. However, the positive predictive value (PPV) which measures the proportion of correct diagnoses was low (30.0%). This result suggests that 70.0% of the pre-school population diagnosed as thin were not wasted. Similarly, the sensitivity and specificity values using the 5th percentile BMI for age were also high for the primary school population, 100% and 83.8%, respectively. However, the PPV was even lower 19.7% suggesting that four out of five primary school-aged children diagnosed as thin were not wasted.

An alternative approach was to adhere to the conventional -2 SD cut-off point currently used to differentiate between the malnourished and adequately nourished when using WHZ and WHZ. To examine if -2 SD provided a closer estimate of the proportion of malnourishment, the prevalence of wasting (-2 WHZ), underweight (-2 WAZ) were compared with the prevalence rates of thinness diagnosed using BMI-for-age (-2 BMIZ) for the pre-school and primary school populations. Since, reference data for BMI-for-age starts at 24 months the pre-school population were reduced to 24-59 months (n=174). The prevalence of wasting amongst the pre-school and primary school population using -2 SD WHZ were 3.4% and 4.1%, respectively. Using the -2 BMIZ-for-age, the prevalence of thinness was approximately double the prevalence of wasting in the pre-school population and three-fold the estimates in primary school population (Table 5.5.36-5.5.41).

Sensitivity and specificity analyses were carried out to compare the performance of -2 BMIZ-for-age indicator to predict child wasting and child underweight. Using -2

BMIZ for age the sensitivity value remained high (100%); as expected the specificity value decreased slightly to 95.8% for the pre-school population and 91.4% for primary school population (Tables 5.5.38-5.5.41). In contrast, the PPV increased substantially to 46.2% amongst the pre-school population and 31.7% amongst the primary school population. It is evident from the sensitivity and specificity analyses that -2 BMIZ is actually more comparable with the -1.5 WHZ cut-off representing mild wasting. Assuming that -2 BMIZ-for-age is also a reasonably valid indicator of adequacy of weight for height for adolescents, the estimated prevalence rate of thinness amongst male and female adolescents using -2 BMIZ were 18.4% and 13.8%, respectively.

5.6.5 Distribution of mean BMI within adult population by gender and age: The overall mean BMI of adult males and females was 20.5±2.3 kg/m² and 23.6±4.5kg/m², respectively. The observed gender difference of 3.1 in the BMI index was highly significant (Table 5.3.35). Throughout adulthood women had a higher BMI measure to men, the gender difference in mean BMI was highly significant between the ages of 18-65 years and after 75 years. When analysed by the three discrete periods of adulthood a highly significant difference was observed between the male and female BMI during young adulthood, middle-age and in old-age (Table 5.3.35).

Within the male population there was a very weak inverse relationship between BMI and age, suggesting that male BMI declined slightly with age (Table 5.3.54). Also, difference in mean BMI by quintal or by each of the three discrete periods of adulthood within the male population were statistically insignificant (Table 5.3.44). In contrast there was a significant curvilinear relationship observed between female BMI and age. The positive age effect and negative age² indicates that female BMI tends to rise with age, plateau and then subsequently decline in old age (Table 5.3.61). The results of the one-way ANOVA used to compare the mean BMI of female adults by the three discrete periods of adulthood was highly significant (p=0.004) (Table 5.3.40). The Games-Howell *a posterior test* indicated that young female adults aged between 18-21.99 years possessed a significantly lower mean BMI (22.0 ± 2.4) compared to their middle-aged counterparts who exhibited the highest mean BMI (24.2 ± 4.6) within the adult population (Table 5.3.40). When the female adult population was disaggregated by quintals a highly significant difference was observed between women aged between 18-21 years who had the lowest mean BMI and women aged 40-45 and 50-55 who had the highest mean BMI measures (Table 5.3.45).

5.6.6 Diagnosis of adult nutritional status using Body Mass Index (BMI): Two approaches were used to examine the prevalence of CED within the adult population, the first categorised BMI into a dichotomous variable using the cut-off of <18.5 kg/m² to indicate CED and adequate nourishment. The second classification differentiated between the three grades of CED: grade I: mild (≥17-18.49 kg/m²); grade II: moderate (≥16-16.99 kg/m²), and grade III: severe (<16 kg/m²), adequate nourishment (≥18.5-24.99 kg/m²), and three grades of overweight/obesity: grade I overweight (≥25-29.99 kg/m²); grade II (≥30-30.99 kg/m²); grade III (≥40 kg/m²), to provide an insight into the extent and severity of the nutrition problem within the adult population as firstly proposed by James *et al* (1988) and presently advocated by FAO (Shetty and James, 1994) and WHO (1995, 2000). The results of the binary classification are presented by gender and for each discrete period of adulthood in (Table 5.5.42). The distribution of seven BMI categories by gender and age group are summarised in (Tables 5.5.43-45).

5.6.7 Prevalence rates of chronic energy deficiency (CED) amongst adults - gender differences: A combination of the overall highly significant difference in mean height and insignificant difference in mean weight between male and female population had a direct impact of the BMI calculations, and hence the classification of nutritional status. Men who were generally taller and lighter than their female counterparts and were significantly more likely to be suffer from CED. In comparison the prevalence rates of overweight and obesity were high amongst females and virtually non-existent amongst men.

The overall mean BMI of males (20.5±2.3 kg/m²) was at the lower end of the adequately nourished category whereas the mean BMI (23.6±4.5kg/m²) of females was at upper end. Men were significantly more likely to be undernourished than women ($p<0.001$). A fifth of male adult population were diagnosed as CED (BMI <18.5 kg/m²) compared to 5.0% of the female population. The relative risk ratio (RR) indicates that incident rate of CED amongst men was double (2.0) the prevalence rate of CED amongst women. The odds risk ratio indicates that prevalence rate of CED was 4.5 (95% CI 2.5-8.4, $p<0.001$) times greater amongst men compared with women. From a public health perspective the prevalence rate of CED observed amongst men was classified as a serious situation whereas amongst women the prevalence rate of CED was categorised as low.

The relatively higher prevalence rate of CED amongst men compared to women was consistently observed throughout adult life. However, the level of significance and risk ratios differed within each discrete period of adulthood. Male youths were 3.4 (95% CI 0.6-18.5) times more likely to have CED compared to their female counterparts. The gender difference in CED prevalence rates observed amongst young adults (18-21.99 years) was statistically insignificant. In constrast, a highly significant gender difference in the prevalence rates of CED was observed amongst the middle-aged. The male odds risk ratio increased to 9.4 (95% CI 3.5-25.7). No significant gender difference in prevalence of CED was observed within the elderly population; the male odds risk ratio was reduced to 1.8 (95% CI 0.7-4.6).

5.6.8 Prevalence rates of chronic energy deficiency (CED) amongst adults - age differences: Within the adult population, the elderly were at significantly higher risk of CED compared with young adults and the middle-aged. Within the male population elderly men were twice as likely to be diagnosed as CED compared to their younger counterparts. The odds risk of CED within female population was even more pronounced and highly significant, elderly women were 8.3 (95% CI 2.9-23.6) times more likely to be diagnosed CED compared to younger women ($p<0.001$) (Table 5.5.45). The age pattern of CED within the male and female population differed.

Within the male population there was distinct positive linear association between CED and age. The prevalence rates of CED of young adult, middle-aged and elderly men were, 12.8%, 17.6% and 28.0%, respectively. Within the female population, middle-aged women had the lowest prevalence rates of CED (2.2%), approximately half that observed amongst young adult females (4.2%) and nine times less than that observed in elderly women (18.0%) (Table 5.5.45).

5.6.9 Extent and severity of CED by gender and age: The prevalence of severe, moderate and mild CED within the adult population was low, 0.7%, 1.7% and 8.2%, respectively. A significant gender difference was evident at all grades of CED. Less than 2% of all females measured were diagnosed with severe or moderate CED compared to 3.7% of the males. The gender difference was most pronounced amongst those diagnosed as mildly CED, approximately one in 29 women had a BMI between (17.00-18.4) compared to one in six men. There was a significant association between age group and the degree of nourishment within the adult population ($p<0.001$). When examined by gender this association between the degree of nourishment and age group was highly significant for females only ($p<0.001$) suggesting that there was less variation in nutritional status within the male population. Severe and moderate cases of CED were primarily confined to the elderly population for both genders. Three of the four cases of severe CED and five of the nine cases of moderate CED were observed amongst the elderly whereas the majority of the 44 cases of mild CED were found amongst the middle-aged within both the male and female population.

5.6.10 Extent and severity of overweight and obesity by gender and age: A highly significant gender disparity also prevailed at the other end of the spectrum; female adults were significantly more likely to be overweight or obese compared to men. Using the binary classification to distinguish between the nourished (<25 kg/m^2) and overly nourished ($\geq$25 kg/m^2), approximately one in four adults (18.1%) were diagnosed as overweight or obese. There was a highly significant association between over-nourishment and gender ($p<0.001$). The incidence rate or relative risk ratio of over-nourishment was 10 times higher amongst women, whereas the odds risk ratio indicated that prevalence rate of over-nourishment was 13.5 (95% CI 5.8-31.6) times greater amongst women compared with men (p<0.001). Amongst the male population 2.8% were overweight and there was no evidence of male obesity. In constrast, overweight and obesity was remarkably prolific amongst the female population. One in five women (19.8%) were diagnosed overweight, a further 7.4% were considered Grade II obese and 0.9% had evidence of Grade III obesity. These results suggest that nearly one in three women exhibit signs of over-nourishment compared to one in 36 men. The gender disparity of nutritional status is clearly evidenced by the divergent CED:obesity ratios. This ratio between the underweight and overweight prevalence provides a measure of the relative dimension of two problems in the population. Amongst males, the large predominance of CED to overweight (more than 6.8:1) was reversed in women (0.2:1).

As observed in developed countries there was a highly significant association between over-nourishment and age (p<0.001). Of the 97 cases of overweight and obesity, 81.4% were observed amongst the middle-aged, 14.4% amongst the elderly and 4.1% within the young adult population. The prevalence of over-nourishment varied significantly by age group (p<0.001). Approximately, one in four (22.6%) of middle-aged were diagnosed overweight or obese, compared with one in seven (14.0%) elderly and one in 22 (4.6%) young adults (Table 5.5.44-45).

5.7 Summary

1. A total of 1,737 household members were measured in Mar-95. Five percent of the total sample were excluded due to pregnancy, lactation or problematic measures. The gender and age distribution of the household members measured reflected the young and female biased demographic profile of the sample population. Two thirds (67.2%) of the sample measured were aged <18 years; 63.9% of the middle-aged adults measured were women.
2. Analyses of the height and weight distribution suggested that overall boys were taller and significantly heavier than girls during infancy. Boys continued to be taller and heavier than girls during middle childhood although the gender differences

were statistically insignificant. Female height and weight intercepted and superseded males at around 11 years of age. This was considered indicative of the start of female pubescence. Female peak height velocity (PHV) was exhibited two years earlier than males. Males exhibit prolonged maturation resulting in substantial compensatory '*catch-up growth*'. This was more pronounced than that observed amongst females. Overall, adolescent males remained predominately taller than females although the gender difference in height was statistically insignificant until adulthood. Although, younger age cohorts within the adult population were taller and there was an inverse correlation between height and age, the inconsistent pattern of mean height with age particularly amongst the male population provided inconclusive results concerning associated secular increases in height.

3. Girls became significantly more ponderous than boys during adolescence. The distinctive sexual dimorphism of fat patterning solely expressed amongst females during adolescence prevailed throughout adulthood and was highly significant during middle-age.
4. Simultaneous analyses of child and adult nutritional status suggested that children faired worst. Mean HAZ, WHZ, WAZ BMIZ were all negative indicating that the children were moderately short and underweight for their age and mildly thin for their height. In comparison, the mean adult BMI of males (20.5±2.3 kg/m^2) and females (23.6±4.5kg/m^2) was situated within the normal category, suggesting that generally adults could not be considered nutritionally at-risk. This finding was unexpected given the marginal drought prone habitat, prevailing environmental conditions and socio-economic demographic poverty profile of the selected households.
5. Using malnutrition prevalence rates generated from anthropometric indices children were considered at high risk of stunting (23.9%), at moderate risk of underweight (15.5%), and at low risk of wasting (5.0%). In comparison, the overall prevalence of CED (<18.5 BMI) amongst adults was 10.6%; a medium risk situation. These prevalence rates of malnourishment are indicative of a chronic food and nutrition insecure situation with high levels of low HA and relatively low levels of WH.

6. The extent of the nutrition problem within the sample population was broad covering the whole spectrum of chronic malnourishment from severe undernourishment to grade III obesity. Within the child population less than a third (29.5%) were categorised as 'adequately nourished' with no degree of stunting or wasting. The majority 40.1% of the children were categorised as stunted but not wasted; of these 23.7% were mildly short for their age and 16.4% were moderate to severely stunted. A sixth (15.2%) were classified as wasted only with no evidence of growth retardation; of these 12.9% were mildly wasted and 2.3% were categorised as moderate to severely wasted. Less than one percent (0.6%) were classified as stunted and wasted, In contrast, the prevalence of severe and moderate CED within the adult population was low, 0.7% and 1.7% respectively. At the other end of the spectrum, the prevalence female over-nourishment was considered high. One in five women (19.8%) were diagnosed overweight, a further 7.4% were considered Grade II obese and 0.9% had evidence of Grade III obesity.
7. Males were nutritionally more at-risk than females throughout the life-span. Male odds ratios of malnourishment were estimated to be: stunting (OR:1.3; 95% CI 1.0-1.7, p=n.s.), underweight (OR:1.1; 95% CI 1.1-1.6, p=n.s.), thinness (OR:1.6; 95% CI 1.2-2.1, $p=0.003$), wasting (OR:1.4; 95% CI 0.7-2.8, p=n.s.), and CED (OR:4.5; 95% CI 2.5-8.4, $p<0.001$). The gender disparity of nutritional status amongst adults was clearly evidenced by the divergent CED:obesity ratios. Amongst males, the large predominance of CED to overweight (6.8:1) was reversed in women (0.2 to 1).
8. In terms of age, pre-school and adolescents were at significantly more risk of stunting and underweight compared with primary school children and the elderly were the most nutritionally vulnerable within the adult population.
9. Significant growth deficits were associated with the two phases of increased growth velocity, namely infancy and adolescence. The risk of stunting increased three fold during these two periods compared with middle childhood. Linear growth retardation emerged in early childhood. It was shown that the high prevalence rates of stunting amongst the pre-school population were partially explained by the disjunction between the FELS and NCHS growth reference data.

CHAPTER 5 - TABLES

Tables for section 5.3

Mean (SD) Height (m): Child gender differences by three discrete periods of childhood										
		Males			Females					
Discrete Period of Childhood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Pre-school	**0-4.99**	143	0.84	0.13	148	0.84	0.13	289	1.09	n.s.
Middle	**5-9.99**	169	1.19	0.09	173	1.18	0.09	342	0.356	n.s.
Adolescence	**10-17.99**	222	1.46	0.13	245	1.46	0.12	465	0.418	n.s.

Table 5.3.1: *Independent t-test comparing mean height (m) of male and female by three discrete periods of childhood (Mar-95)*

Mean (SD) Height (m): Adult gender differences by three discrete periods of adulthood										
		Males			Females					
Discrete Period of Adulthood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Youth	**18-21.99**	39	1.70	0.07	48	1.60	0.07	85	7.045	<0.001
Middle-age	**22-59.99**	125	1.70	0.06	225	1.59	0.06	348	16.367	<0.001
Elderly	**≥60**	50	1.69	0.07	50	1.57	0.06	98	9.110	<0.001
All	≥18	214	1.70	0.07	323	1.59	0.06	535	19.695	<0.001

Table 5.3.2: *Independent t-test comparing mean height (m) of male and female by three discrete periods of adulthood (Mar-95)*

Mean (SD) Height (m): Pre-school children (0-4.99 years)													
Age (months)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
0-11	55	0.65	0.06	29	0.65	0.06	26	0.65	0.07				
12-23	53	0.75	0.04	24	0.76	0.04	29	0.74	0.04	Age	4	471.352	<0.001
24-35	42	0.85	0.04	21	0.85	0.03	21	0.85	0.04	Sex	1	3.380	n.s.
36-47	61	0.92	0.05	31	0.94	0.04	30	0.90	0.05	Age*sex	4	1.842	n.s.
48-59	72	0.99	0.05	32	0.98	0.04	40	0.99	0.05				
All	283	0.84	0.13	137	0.84	0.13	146	0.84	0.13				

Table 5.3.4: *One-way ANOVA comparing pre-school mean height (m) by yearly age classes, gender, examining gender*age interactions (Mar-95)*

Mean (SD) Height (m): Primary school children (5-9.99 years)													
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
5-5.99	64	1.078	0.054	34	1.086	0.593	30	1069	0.473				
6-6.99	59	1.134	0.057	29	1.142	0.584	30	1127	0.553	Age	4	127.288	<0.001
7-7.99	73	1.183	0.056	36	1.173	0.469	37	1194	0.630	Sex	1	0.486	n.s.
8-8.99	60	1.227	0.056	22	1.218	0.558	38	1232	0.569	Age*sex	4	2.034	n.s.
9-9.99	86	1.275	0.063	48	1.285	0.573	38	1263	0.690				
All	342	1.186	0.099	169	1.188	0.913	173	1184	0.908				

Table 5.3.5:*One-way ANOVA comparing primary school mean height (m) by yearly age classes, gender and gender*age interactions (Mar-95)*

Mean (SD) Height (m): Adolescents (10-17.99 years)													
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
10-10.99	92	1.329	0.069	42	1.338	0.064	50	1.321	0.073				
11-11.99	68	1.397	0.0730	28	1.388	0.054	40	1.403	0.084				
12-12.99	76	1.410	0.0770	38	1.386	0.068	38	1.433	0.079	Age	7	99.934	<0.001
13-13.99	57	1.482	0.087	26	1.471	0.089	31	1.491	0.085	Sex	1	0.597	n.s.
14-14.99	57	1.526	0.089	31	1.521	0.098	26	1.532	0.078	Age*sex	7	2.358	0.023
15-15.99	46	1.556	0.080	18	1.553	0.099	28	1.558	0.067				
16-16.99	47	1.597	0.076	28	1.612	0.070	19	1.575	0.079				
17-17.99	24	1.607	0.075	11	1.642	0.093	13	1.578	0.039				
All	467	1.458	0.122	222	1.461	0.127	245	1.456	0.117				

Table 5.3.6: *One-way ANOVA comparing adolescent mean height (m) by yearly age classes, gender and gender*age interactions (Mar-95*

Mean (SD) Height (m): Adult male by three discrete periods of adulthood						
Discrete period adulthood	**Age (years)**	**n**	**Height (m) Mean SD**	**DF**	***F***	***p***
Youth	**18-21.99**	39	1.701 ± 7.1			
Middle-age	**22-59.99**	125	1.701 ± 6.3	2	0.652	n.s.
Elderly	**≥60**	50	1.689 ± 7.0			

Table 5.3.7: *One-way ANOVA comparing mean male height (m) by 3 discrete periods of adulthood*

Mean (SD) Height (m): Adult male by quintal age intervals					
Age (years)	**n**	**Height (m) Mean SD**	**DF**	***F***	***p***
18-21.99	39	1.701 ± 0.071			
22-24.99	16	1.697 ± 0.054			
25-29.99	20	1.698 ± 0.052			
30-34.99	12	1.724 ± 0.073			
35-39.99	23	1.719 ± 0.056			
40-44.99	14	1.680 ± 0.062	12	0.790	n.s.
45-49.99	13	1.696 ± 0.076			
50-54.99	11	1.695 ± 0.081			
55-59.99	16	1.694 ± 0.062			
60-64.99	16	1.713 ± 0.065			
65-69.99	5	1.667 ± 0.063			
70-74.99	15	1.684 ± 0.073			
≥75	14	1.675 ± 0.075			

Table 5.3.8: *One-way ANOVA comparing mean adult male height (m) by quintal*

Mean (SD) Height (m): Adult female by three discrete periods of adulthood						
Discrete period adulthood	**Age (years)**	**n**	**Height (m) Mean SD**	**DF**	***F***	***p***
Youth	**18-21.99**	41	1.595 ± 6.9			
Middle-age	**22-59.99**	30	1.592 ± 5.8	2	4.185	0.016
Elderly	**≥60**	20	1.566 ± 6.4			

Table5.3.9: *One-way ANOVA comparing mean female height (m) by 3 discrete periods of adulthood*

Mean (SD) Height (m): Adult Female by quintal age intervals					
Age (years)	**n**	**Height (m) Mean SD**	**DF**	***F***	***p***
18-21.99	41	1.595 ± 0.069			
22-24.99	21	1.586 ± 0.044			
25-29.99	20	1.610 ± 0.046			
30-34.99	35	1.596 ± 0.063			
35-39.99	43	1.583 ± 0.052			
40-44.99	30	1.608 ± 0.065	12	2.225	0.011
45-49.99	35	1.610 ± 0.054			
50-54.99	24	1.571 ± 0.058			
55-59.99	17	1.564 ± 0.062			
60-64.99	16	1.574 ± 0.067			
65-69.99	14	1.581 ± 0.056			
70-74.99	11	1.557 ± 0.084			
≥75	9	1.540 ± 0.042			

Table 5.3.10: *One-way ANOVA comparing mean adult female height (m) by quintal*

Mean (SD) Weight (kg): Child gender differences by three discrete periods of childhood										
		Males			Females					
Discrete Period of Childhood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Pre-school	**0-4.99**	142	11.4	3.3	148	11.1	3.2	288	0.98	n.s.
Middle	**5-9.99**	172	20.9	3.7	175	20.6	3.7	345	0.796	n.s.
Adolescence	**10-17.99**	223	35.8	10.0	246	36.8	10.7	466	-1.109	n.s.

Table 5.3.11: *Results of independent t-test comparing mean weight (kg) of males and females by three discrete age groups (Mar-95)*

Mean (SD) Weight (kg): Adult gender differences by three discrete periods of adulthood										
		Males			Females					
Discrete Period ofAdulthood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Youth	**18-21.99**	39	59.3	7.2	48	56.1	7.7	85	1.982	n.s.
Middle-age	**22-59.99**	127	59.3	7.3	227	61.4	11.9	352	-2.079	0.038
Elderly	**≥ 60**	50	57.6	8.8	50	55.8	13.9	98	0.775	n.s.
All	**≥18**	216	58.9	7.7	325	59.8	11.9	539	-0.940	n.s.

Table 5.3.12: *Results of independent t-test comparing mean weight (kg) of male and female by three discrete periods of adulthood (Mar-95)*

					Mean (SD) Weight (kg) Pre-school children (0-4.99 years)								
Age (months)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
0-11	59	6.8	1.6	32	6.9	1.6	27	6.8	1.6				
12-23	53	9.1	1.2	24	9.6	1.4	29	8.6	0.9	Age	4	278.913	<0.001
24-35	43	11.7	1.5	22	11.9	1.4	21	11.5	1.5	Sex	1	11.956	0.001
36-47	63	13.2	1.6	31	13.9	1.5	32	12.6	1.5	Age*sex	4	1.893	n.s.
48-59	72	14.4	1.5	33	14.5	1.3	39	14.3	1.7				
All	290	11.2	3.2	142	11.4	3.3	148	11.1	3.2				

Table 5.3.14: *One-way ANOVA comparing pre-school mean weight (kg) by yearly age classes, gender, examining gender*age interactions (Mar-95)*

					Mean (SD) Weight (kg) Primary school children (5-9.99 years)								
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
5-5.99	66	17.1	2.5	35	17.5	3.0	31	16.7	1.8				
6-6.99	58	18.6	2.4	29	18.9	2.4	29	18.4	2.4	Age	4	81.116	<0.001
7-7.99	75	20.2	2.6	37	20.0	2.0	38	20.4	3.1	Sex	1	1.316	n.s.
8-8.99	62	22.2	2.9	23	20.0	2.8	39	22.3	2.9	Age*sex	4	0.735	n.s.
9-9.99	86	24.3	3.0	48	24.6	2.8	38	23.8	3.2				
All	347	20.7	3.7	172	20.9	3.7	175	20.6	3.7				

Table 5.3.15:*One-way ANOVA comparing primary school mean weight (kg) by yearly age classes, gender and gender*age interactions (Mar-95)*

					Mean (SD) Weight (kg) Adolescents (10-17.99 years)								
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
10-10.99	93	27.0	4.5	42	27.5	3.4	51	26.6	5.1				
11-11.99	69	30.7	4.7	28	29.3	2.7	41	31.6	5.6				
12-12.99	76	31.5	5.1	38	30.5	4.1	38	32.6	5.8	Age	7	96.060	<0.001
13-13.99	57	37.2	7.9	26	35.9	7.8	31	38.3	8.0	Sex	1	7.978	0.005
14-14.99	57	40.0	7.6	31	38.9	8.1	26	41.2	6.9	Age*sex	7	2.162	0.036
15-15.99	45	45.7	9.5	18	41.8	8.5	27	48.3	9.3				
16-16.99	47	49.1	8.9	28	47.8	8.6	19	50.9	9.3				
17-17.99	24	51.0	7.4	11	53.3	7.8	13	48.9	6.6				
All	468	36.3	10.4	222	35.8	10.0	246	36.8	10.7				

Table 5.3.16: *One-way ANOVA comparing adolescent mean weight (kg) by yearly age classes, gender and gender*age interactions (Mar-95)*

Mean (SD) Weight (kg): Adult males by 3 discrete periods of adulthood							
Discrete period adulthood	**Age (years)**	**n**	**Weight* (kg) Mean SD**	**Main effect**	**df**	***F***	***p***
Youth	**18-21.99**	39	59.2 ± 6.4				
Middle-age	**22-59.99**	127	59.4 ± 6.4	height	1	84.072	<0.001
Elderly	**≥60**	50	58.2 ± 6.5	age group	2	0.542	n.s.
All	**≥18**	213	58.9 ± 7.3				

Table 5.3.17: *One-way ANCOVA results comparing *adjusted mean male weight (kg) after controlling for height by three discrete periods of adulthood (Mar-95)*

Mean (SD) Weight (kg): Adult males by quintal age intervals							
Age (years)	**n**	**Mean**	**SD**	**Main effect**	**DF**	***F***	***p***
18-21.99	39	59.3	7.2				
22-24.99	16	60.1	5.6				
25-29.99	20	59.9	7.3				
30-34.99	12	60.2	7.2				
35-39.99	23	60.2	7.4	Height	1	76.487	<0.001
40-44.99	14	58.2	7.4	Age group	12	0.596	n.s.
45-49.99	13	59.3	8.8				
50-54.99	11	56.5	6.0				
55-59.99	18	58.8	8.9				
60-64.99	16	61.5	9.7				
65-69.99	5	54.2	7.7				
70-74.99	15	56.6	8.4				
≥75	14	55.5	7.7				

Table 5.3.18: *One-way ANCOVA comparing *adjusted mean male weight (kg) after controlling for height by quintal age groups ≥ 25 years (Mar-95)*

Mean (SD) Weight (kg): Adult females by three discrete periods of adulthood											
Discrete period adulthood	**Age (years)**	**n**	**Weight Mean**	**SD**	**Main effect**	**df**	***F***	***p***	**Weight Median**	**H**	***p***
Youth	18-21.99	48	55.8	11.0					54.8		
Middle-age	22-59.99	227	61.1	11.1	Height	1	31.953	<0.001	58.8	17.491	<0.001
Elderly	≥60	50	57.1	11.2	Age grp	2	6.112	0.002	54.0		
All	≥18	325	58.0	14.1							

Table 5.3.19: *One-way ANOVA comparing *adjusted mean male weight (kg) after controlling for height and Kruskal-Wallis one-way analysis of variance comparing mean female weight (kg) by three discrete periods of adulthood (Mar-95)*

Mean (SD) Weight (kg): Adult females by quintal age intervals										
Age (years)	**n**	**Weight* Mean**	**SD**	**Main effect**	**df**	***F***	***p***	**Weight Median**	**H**	***p***
18-21.99	48	56.1	7.7					54.8		
22-24.99	21	56.9	7.6					55.4		
25-29.99	20	58.6	8.7					55.3		
30-34.99	35	57.5	9.6					55.2		
35-39.99	45	59.9	11.1	Height	1	33.210	<0.001	59.3		
40-44.99	30	66.1	14.1	Age grp	12	3.030	<0.001	66.6	34.838	<0.001
45-49.99	35	64.5	10.5					63.7		
50-54.99	24	64.7	16.1					59.0		
55-59.99	17	63.2	13.4					58.1		
60-64.99	16	58.4	18.1					54.4		
65-69.99	14	54.8	8.7					54.3		
70-74.99	11	54.1	15.3					47.2		
≥75	9	54.8	11.6					54.3		

Table 5.3.20: *One-way ANOVA comparing *adjusted mean male weight (kg) after controlling for height and Kruskal-Wallis one-way analysis of variance comparing mean adult female weight by quintal age groups (Mar-95)*

Mean (SD) MUAC (cm): Child gender differences by three discrete period of childhood										
		Males			Females					
Discrete Period of Childhood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Pre-school	**0-4.99**	106	14.6	1.3	113	14.4	1.2	217	1.314	n.s.
Middle	**5-9.99**	155	15.6	1.2	159	15.7	1.2	312	-0.213	n.s.
Adolescence [a]	**10-17.99**	202	19.1	2.6	233	20.0	3.1	432.5	-3.253*	0.001

Table 5.3.21: *Independent t-test results comparing gender difference mean MUAC (cm) by the three distinct periods of childhood (Mar-95) *Unequal variances*

a. Adolescents: Mann-Whitney U-test Z=-3.103, p=0.002

Mean (SD) MUAC (cm): Adult gender differences by three discrete periods of adulthood										
		Males			Females					
Discrete Period of Adulthood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Youth	**18-21.99**	33	24.7	2.4	36	26.5	2.2	67	-1.432	n.s.
Middle-age [a]	**22-59.99**	92	26.0	2.1	195	29.0	3.8	277	-8.463*	<0.001
Elderly	**≥ 60**	44	25.5	2.7	40	281	3.6	82	-3.808	<0.001
Total Pop. [b]	**≥18**	169	25.8	2.3	271	28.5	3.7	438	-9.503*	<0.001

Table 5.3.22: *Independent t-test results comparing gender difference mean MUAC (cm) by the three distinct periods of adulthood (Mar-95) *Unequal variances*

a. Middle-age: Mann-Whitney U-test Z=-6.618, p<0.001

b. Total Pop.: Mann-Whitney U-test Z=-7.831, p<0.001

Mean (SD) Mid-upper arm circumference (MUAC) (cm): Pre-school children (0-4.99 years)													
Age (months)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
0-11	27	13.7	1.7	13	13.7	1.8	14	13.8	1.7				
12-23	44	13.9	1.1	20	14.2	1.3	24	13.6	0.9	Age	4	8.257	<0.001
24-35	36	14.8	1.1	19	14.7	1.0	17	14.8	1.3	Sex	1	1.506	n.s.
36-47	51	14.9	1.2	27	15.1	1.2	24	14.6	1.1	Age*sex	4	0.854	n.s.
48-59	61	14.7	1.0	27	14.7	1.0	34	14.8	1.1				
All	219	14.5	1.3	106	14.6	1.3	113	14.4	1.2				

Table 5.3.26: *One-way ANOVA comparing pre-school mean MUAC (cm) by yearly age classes, gender, examining gender*age interactions Mar-95*

Mean (SD) Mid-upper arm circumference (MUAC) (cm): Primary school children (5-9.99 years)													
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
5-5.99	54	15.1	1.1	28	15.0	1.2	26	15.1	0.9				
6-6.99	55	15.2	1.0	28	15.1	1.0	27	15.3	1.1	Age	4	15.750	<0.001
7-7.99	65	15.5	1.0	32	15.3	0.9	33	15.7	1.2	Sex	1	1.598	n.s.
8-8.99	57	15.9	1.2	20	15.9	1.1	37	16.0	1.2	Age*sex	4	0.302	n.s.
9-9.99	83	16.3	1.1	47	16.3	1.1	36	16.3	1.2				
All	314	15.7	1.2	155	15.6	1.2	159	15.7	1.2				

Table 5.3.27:*One-way ANOVA comparing primary school mean MUAC (cm) by yearly age classes, gender and gender*age interactions (Mar-95)*

Mean (SD) Mid-upper arm circumference (MUAC) (cm): Adolescents (10-17.99 years)													
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
10-10.99	89	17.3	1.4	40	17.1	1.1	49	17.4	1.6				
11-11.99	63	17.9	1.5	23	17.4	0.9	40	18.3	1.7				
12-12.99	74	18.3	1.5	37	17.9	1.2	37	18.7	1.7	Age	7	73.549	<0.001
13-13.99	54	19.7	2.4	25	19.1	1.8	29	20.2	2.8	Sex	1	35.141	<0.001
14-14.99	52	20.5	2.2	27	19.8	2.2	25	21.2	2.0	Age*sex	7	3.730	0.001
15-15.99	40	21.9	3.0	17	19.8	2.0	23	23.5	2.6				
16-16.99	42	23.0	2.6	23	22.3	2.4	19	23.9	2.7				
17-17.99	21	24.0	2.4	10	24.3	2.4	11	23.7	2.5				
All	435	19.5	2.9	202	19.1	2.6	233	20.0	3.1				

Table 5.3.28: *One-way ANOVA comparing adolescent mean MUAC (cm) by yearly age classes, gender and gender*age interactions (Mar-95)*

Mean (SD) MUAC: Children (2-6 years) (Sexes combined) by yearly age classes					
Age (years)	**n**	**MUAC (cm) Mean SD**	**DF**	***F***	***p***
2-2.99	36	14.8 ± 1.1			
3-3.99	51	14.9 ± 1.2			
4-4.99	61	14.7 ± 1.0	4	1.693	n.s.
5-5.99	54	15.1 ± 1.1			
6-6.99	55	15.2 ± 1.0			

Table 5.3.29: *One-way ANOVA comparing mean MUAC (cm)of children aged between 2-6 years (sexes combined) by yearly age classes (Mar-95)*

Mean (SD) MUAC (cm): Adult males by 3 discrete periods of adulthood						
Discrete period adulthood	**Age (years)**	**n**	**MUAC (cm) Mean SD**	**DF**	***F***	***p***
Youth	**18-21.99**	33	25.8 ± 1.9			
Middle-age	**22-59.99**	92	26.0 ± 2.1	2	0.777	n.s.
Elderly	**≥60**	44	25.8 ± 2.7			

Table 5.3.30: *One-way ANOVA results comparing mean male MUAC (cm) by three discrete periods of adulthood (Mar-95)*

Mean (SD) MUAC: Adult males (≥18 years)					
Age (years)	**n**	**MUAC (cm) Mean SD**	**DF**	***F***	***p***
18-21.99	33	25.8 ± 1.9			
22-24.99	13	26.1 ± 2.0			
25-29.99	11	26.3 ± 2.3			
30-34.99	10	25.5 ± 2.6			
35-39.99	18	26.1 ± 2.2			
40-44.99	8	26.0 ± 1.7	12	0.721	n.s.
45-49.99	10	25.9 ± 1.8			
50-54.99	10	25.4 ± 1.5			
55-59.99	12	26.6 ± 2.9			
60-64.99	15	26.5 ± 3.0			
65-69.99	2	24.1 ± 2.1			
70-74.99	14	25.3 ± 2.8			
≥75	13	24.7 ± 2.4			

Table 5.3.31: *One-way ANOVA comparing adult male mean MUAC (cm) by quintal age groups (Mar-95)*

Mean (SD) MUAC (cm): Adult females by 3 discrete periods of adulthood										
Discrete period adulthood	**n**	**Mean**	**SD**	**df**	***F***	***p***	**Median**	**df**	**H**	***p***
Youth 18-21.99	36	26.5	2.2				26.5			
Middle-age 22-59.99	195	29.0	3.8	2	7.454	0.001	28.5	2	14.779	0.001
Elderly ≥60	40	28.1	3.6				28.5			

Table 5.3.32: *One-way ANOVA and Kruskal-Wallis one-way analysis of variance comparing mean adult female MUAC (cm) by three discrete periods of adulthood (Mar-95)*

Mean (SD) MUAC (cm): Adult females by quintal age intervals										
Age (yrs)	**n**	**Mean**	**SD**	**df**	***F***	***p***	**Median**	**df**	**H**	***p***
18-21.99	36	26.5	2.2				26.5			
22-24.99	20	26.9	2.4				26.5			
25-29.99	16	27.1	2.5				26.7			
30-34.99	28	27.2	3.0				26.5			
35-39.99	35	28.8	3.2				28.5			
40-44.99	27	30.0	4.8	12	4.696	<0.001	29.0	12	46.892	<0.001
45-49.99	32	30.0	3.1				30.0			
50-54.99	22	30.8	4.5				29.8			
55-59.99	15	30.9	4.7				30.8			
60-64.99	15	28.2	4.1				29.0			
65-69.99	12	27.3	2.5				27.3			
70-74.99	6	26.8	3.0				27.8			
≥75	7	30.3	3.9				31.9			

Table 5.3.33: *One-way ANOVA and Kruskal-Wallis one-way analysis of variance comparing mean adult female MUAC (cm) by quintal age groups (Mar-95)*

Mean (SD) BMI: Child gender differences by three discrete period of childhood										
		Males			Females					
Discrete Period of Childhood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Pre-school	**0-4.99**	136	15.9	1.7	145	15.5	1.6	279	2.288	0.023
Middle	**5-9.99**	169	14.7	1.0	172	14.6	1.2	339	1.197	n.s.
Adolescence [a]	**10-17.99**	222	16.4	1.8	244	17.0	2.7	431	-2.766*	0.006

Table 5.3.34: *Independent t-test comparing gender difference mean BMI by the three distinct periods of childhood (Mar-95) *Equal variances not assumed*

a. Adolescents: Mann-Whitney U-test Z=1.702, n.s.

Mean (SD) MUAC (cm): Adult gender differences by three discrete periods of adulthood										
		Males			Females					
Discrete Period of Adulthood	**Age (years)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**df**	***t***	***p***
Youth	**18-21.99**	39	20.5	1.8	48	22.0	2.4	85	-3.382	0.001
Middle-age [a]	**22-59.99**	124	20.5	2.2	225	24.2	4.6	340	-10.094*	<0.001
Elderly	**≥ 60**	50	20.2	2.7	50	22.8	5.4	71.2	-3.022*	0.003
Total Pop. [b]	**≥18**	213	20.4	2.2	323	23.6	4.5	499	-10.862	<0.001

Table 5.3.35: *Independent t-test results comparing gender difference mean BMI by the three distinct periods of adulthood (Mar-95) *Equal variances not assumed*

a. Middle-age: Mann-Whitney U-test Z=-8.467, $p<0.001$

b. Total Pop.: Mann-Whitney U-test Z=-9.615, $p<0.001$

Mean (SD) BMI: Male children (0-17.99 years)						
Discrete period of childhood	**Age (years)**	**n**	**BMI Mean SD**	**df**	***F***	***p***
Pre-school	**0-4.99**	136	15.9 ± 1.7			
Middle	**5-9.99**	169	14.7 ± 1.0	2	59.268	<0.001
Adolescence	**10-17.99**	222	16.4 ± 1.8			

Table 5.3.37: *One-way ANOVA comparing mean BMI of male children by three discrete periods of childhood (Mar-95)*

Mean (SD) BMI: Female children (0-17.99 years) by 3 discrete periods of childhood										
Discrete period adulthood	**n**	**Mean**	**SD**	**df**	***F***	***p***	**Median**	**df**	**H**	***p***
Pre-school 0-4.99 yr.	145	15.5	1.6				15.4			
Middle 5-9.99 yr.	172	14.6	1.2	2	75.003	<0.001	14.6	2	120.485	<0.001
Adolescence 10-17.99 yr.	244	17.0	2.7				16.5			

Table 5.3.38: *One-way ANOVA and Kruskal-Wallis one-way analysis of variance comparing mean BMI of female children by three discrete periods of childhood (Mar-95)*

Mean (SD) BMI: Adult males (≥18 years) by 3 discrete periods of adulthood						
Discrete period adulthood	**Age (years)**	**n**	**BMI Mean SD**	**DF**	***F***	***p***
Youth	**18-21.99**	39	20.5 ± 1.8			
Middle-age	**22-59.99**	124	20.5 ± 2.2	2	0.490	n.s.
Elderly	**≥60**	50	20.2 ± 2.7			

Table 5.3.39: *One-way ANOVA comparing mean male BMI by three discrete periods of adulthood (Mar-95)*

Mean (SD) BMI: Adult females (≥18 years) by 3 discrete periods of adulthood										
Discrete period adulthood	**n**	**Mean**	**SD**	**df**	***F***	***p***	**Median**	**df**	**H**	***p***
Youth 18-21.99 yr.	48	22.0	2.4				22.1			
Middle-age 22-59.99 yr.	225	24.2	4.6	2	5.750	0.004	23.2	2	13.802	0.001
Elderly ≥60 yr.	50	22.8	5.4				21.7			

Table 5.3.40: *One-way ANOVA and Kruskal-Wallis one-way analysis of variance comparing mean BMI of female adults by three discrete periods of adulthood (Mar-95)*

Mean (SD) Body Mass Index (BMI): Pre-school children (0-4.99 years)													
	All			Male [a]			Female [b]						
Age (months)	n	Mean	SD	n	Mean	SD	n	Mean	SD	Main effect	df	F	p
0-11	54	15.9	2.2	28	15.9	2.0	26	15.9	2.4				
12-23	53	16.1	1.6	24	16.6	1.5	29	15.8	1.6	Age	4	6.757	<0.001
24-35	42	16.3	1.4	21	16.5	1.4	21	16.1	1.3	Sex	1	5.033	0.026
36-47	61	15.6	1.4	31	15.8	1.6	39	15.4	1.2	Age*sex	4	0.372	n.s.
48-59	71	14.9	1.3	32	15.2	1.5	39	14.7	1.1				
All	281	15.7	1.7	136	15.9	1.7	145	15.5	1.6				

Table 5.3.41: *One-way ANOVA comparing pre-school mean BMI by yearly age classes, gender, examining gender*age interactions (Mar-95)*

a. One-way ANOVA males only: F=3.197, df = 4, p=0.015; b. One-way ANOVA females only: F=3.805, df = 4, p=0.006.

Mean (SD) Body Mass Index (BMI): Primary school children (5-9.99 years)													
	All			Male [a]			Female [b]						
Age (years)	n	Mean	SD	n	Mean	SD	n	Mean	SD	Main effect	df	F	p
5-5.99	64	14.7	1.3	34	14.9	1.4	30	14.6	1.3				
6-6.99	58	14.5	0.9	29	14.4	0.9	29	14.5	0.9	Age	4	2.315	n.s.
7-7.99	73	14.4	1.1	36	14.5	0.8	37	14.3	1.4	Sex	1	1.202	n.s.
8-8.99	60	14.7	1.2	22	14.8	1.1	38	14.6	1.3	Age*sex	4	0.325	n.s.
9-9.99	86	14.9	0.9	48	14.9	0.8	38	14.7	0.9				
All	341	14.6	1.1	169	14.7	1.0	172	14.6	1.2				

Table 5.3.42: *One-way ANOVA comparing primary school mean BMI by yearly age classes, gender, examining gender*age interactions (Mar-95)*

a. One-way ANOVA males only: F=1.683, df = 4, n.s.; b. One-way ANOVA females only: F=1.005, df = 4, n.s.

Mean (SD) Body Mass Index (BMI): Adolescents (10-17.99 years)													
	All			Male [a]			Female [b c]						
Age (years)	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Main effect**	**df**	***F***	***p***
10-10.99	92	15.2	1.2	42	15.3	0.8	50	15.1	1.4				
11-11.99	68	15.6	1.3	28	15.2	1.1	40	15.9	1.3				
12-12.99	76	15.8	1.3	38	15.8	1.0	38	15.7	1.5	Age	7	49.941	<0.001
13-13.99	57	16.8	2.1	26	16.4	1.5	31	17.1	2.5	Sex	1	18.895	<0.001
14-14.99	57	17.0	1.7	31	16.6	1.5	26	17.5	1.9	Age*sex	7	4.593	<0.001
15-15.99	45	18.7	2.8	18	17.2	1.8	27	19.8	2.9				
16-16.99	47	19.1	2.5	28	18.3	2.0	19	20.4	2.7				
17-17.99	24	19.6	1.7	11	19.7	1.2	13	19.6	2.0				
All	466	16.7	2.3	222	16.4	1.8	244	17.0	2.7				

Table 5.3.43: *One-way ANOVA comparing primary school mean BMI by yearly age classes, gender, examining gender*age interactions (Mar-95)*

a. One-way ANOVA males only: F=25.313, df = 7, $p<0.001$; b. One-way ANOVA females only: F=29.495, df =7 , $p<0.001$

c. Kruskal-Wallis one-way analysis of variance H=111.736, df =7, $p<0.001$.

Mean (SD) BMI: Males Adults (≥18 years)					
Age (years)	**n**	**Mean SD**	**DF**	***F***	***p***
18-21.99	39	20.5 ± 1.8	12	0.574	n.s.
22-24.99	16	20.9 ± 1.6			
25-29.99	20	20.8 ± 2.1			
30-34.99	12	20.3 ± 1.9			
35-39.99	23	20.4 ± 2.3			
40-44.99	13	20.7 ± 2.1			
45-49.99	13	20.6 ± 2.4			
50-54.99	11	19.6 ± 1.2			
55-59.99	16	20.9 ± 3.1			
60-64.99	16	20.9 ± 3.0			
65-69.99	5	19.4 ± 1.7			
70-74.99	15	20.0 ± 2.8			
≥75	14	19.8 ± 2.4			

Table 5.3.44: *One-way ANOVA comparing mean adult male BMI by and by quintal age groups*

Mean (SD) BMI: Adult Females (≥18 years) by quintal age intervals										
Age (yrs)	**n**	**Mean**	**SD**	**df**	***F***	***p***	**Median**	**df**	**H**	***p***
18-21.99	48	22.0	2.4	12	3.004	0.001	22.1	12	35.212	<0.001
22-24.99	21	20.6	2.8				22.7			
25-29.99	20	22.5	2.7				21.5			
30-34.99	35	22.6	4.0				21.9			
35-39.99	43	23.6	3.3				23.8			
40-44.99	30	25.7	6.2				24.5			
45-49.99	35	24.9	3.5				24.8			
50-54.99	14	26.2	6.5				24.8			
55-59.99	17	25.8	5.1				26.0			
60-64.99	16	23.6	6.9				22.1			
65-69.99	14	21.9	3.2				21.0			
70-74.99	11	22.4	6.5				21.7			
≥75	9	23.0	4.2				24.5			

Table 5.3.45: *One-way ANOVA and Kruskal-Wallis one-way analysis of variance comparing mean adult female BMI by quintal age groups (Mar-95)*

Tables for section 5.4

Mean (SD) HAZ : Male and Female children (0-17.99 years)								
		Males		Females				
Discrete Period of Childhood	**Age (years)**	**n**	**HAZ Mean SD**	**n**	**HAZ Mean SD**	**DF**	***t***	***p***
Pre-school	**0-4.99**	137	-1.4 ± 1.2	281	-1.2 ± 1.3	281	-0.082	n.s.
Middle	**5-9.99**	169	-1.1 ± 1.0	340	-0.9 ± 1.0	340	-1.359	n.s.
Adolescence	**10-17.99**	222	-1.5 ± 1.1	465	-1.2 ± 1.1	465	-3.043	0.002
ALL	**0-17.99**	528	-1.3 ± 1.1	564	-1.1 ± 1.1	1090	-3.023	0.003

Table 5.4.1: *Results of independent t-test comparing gender difference mean HAZ by the three distinct periods of childhood for the cross-sectional sample (Mar-95)*

Mean (SD) Height for Age (HAZ): Three discrete periods of childhood by gender and survey round										
Age	**Total Pop.**		**Male**		**Female**					
years	**n**	**Mean SD**	**n**	**Mean SD**	**n**	**Mean SD**	**Main effect**	**df**	**F**	***p***
0-4.99	283	-1.3 ± 1.2	137	-1.4 ± 1.2	146	-1.2 ± 1.3	Age group	2	11.266	<0.001
5-9.99	342	-1.0 ± 1.0	169	-1.1 ± 1.0	173	-0.9 ± 1.0	Sex	1	9.770	0.002
10-17.99	467	-1.4 ± 1.1	222	-1.5 ± 1.1	245	-1.2 ± 1.1	Sex age int.	2	0.844	n.s.
ALL	1092	-1.2 ± 1.1	528	-1.3 ± 1.1	564	-1.4 ± 1.1				

Table 5.4.2: *One-way ANOVA comparing mean HAZ by three discrete periods for the whole child population by age group and gender (Mar-95)*

Distribution of Male and Female Mean (SD) HAZ throughout childhood							
	Males		Females				
Age group (years)	**n**	**HAZ Mean SD**	**n**	**HAZ Mean SD**	**DF**	***t***	***p***
0-5 mths	13	-0.4 ± 1.2	13	-0.2 ± 1.2	24	-1.450	n.s.
6-11 mths	16	-0.8 ± 1.5	13	0.09 ± 1.1	27	-1.692	n.s.
1-1.99	24	-1.7 ± 1.2	29	-1.6 ± 1.1	51	-0.230	n.s.
2-2.99	21	-1.4 ± 1.0	21	-1.4 ± 1.2	40	0.047	n.s.
3-3.99	31	-1.3 ± 1.0	30	-1.8 ± 1.2	59	1.815	n.s.
4-4.99	32	-1.8 ± 0.9	40	-1.2 ± 1.1	70	-1.849	n.s.
5-5.99	34	-0.9 ± 1.1	30	-0.9 ± 0.9	62	-0.005	n.s.
6-6.99	29	-0.9 ± 1.1	30	-0.9 ± 1.0	57	0.040	n.s.
7-7.99	36	-1.3 ± 0.9	37	-0.7 ± 1.0	71	-2.817	0.006
8-8.99	22	-1.4 ± 0.9	38	-0.9 ± 0.9	58	-1.818	n.s.
9-9.99	48	-1.0 ± 1.0	38	-1.2 ± 0.9	84	1.153	n.s.
10-10.99	42	-1.0 ± 1.0	50	-1.3 ± 1.0	90	1.389	n.s.
11-11.99	28	-1.1 ± 0.7	40	-1.1 ± 1.2	66	-0.123	n.s.
12-12.99	38	-1.8 ± 0.9	38	-1.6 ± 1.2	74	-0.696	n.s.
13-13.99	26	-1.4 ± 1.1	31	-1.5 ± 1.2	55	0.230	n.s.
14-14.99	31	-1.7 ± 1.1	26	-1.2 ± 1.2	55	-1.468	n.s.
15-15.99	18	-1.9 ± 1.2	28	-0.9 ± 1.0	44	-3.010	0.004
16-16.99	28	-2.0 ± 1.0	19	-0.8 ± 1.2	45	-3.779	<0.001
17-17.99	11	-1.9 ± 1.4	13	-0.9 ± 0.6	22	-2.290	0.032

Table 5.4.3: *Independent t-test comparing mean HAZ of males and females by yearly age classes between ages 0-17.99 years for the cross-sectional sample Mar-95*

Mean (SD) Height for Age (HAZ): Pre-school children (0-4.99 years)										
Age	Total Pop.		Males		Females					
months	n	Mean SD	n	Mean SD	n	Mean SD	Main effect	df	F	*p*
0-11	55	-0.2 ± 1.3	29	-0.6 ± 1.3	26	-0.2 ± 1.2				
12-23	53	-1.7 ± 1.1	24	-1.7 ± 1.2	29	-1.6 ± 1.1	Age group	4	15.402	<0.001
24-35	42	-1.4 ± 1.1	21	-1.4 ± 1.0	21	-1.4 ± 1.2	Sex	1	1.640	n.s.
36-47	61	-1.5 ± 1.1	31	-1.3 ± 1.0	30	-1.8 ± 1.2	Sex age int.	4	2.761	0.028
48-59	72	-1.6 ± 1.1	32	-1.8 ± 0.9	40	-1.2 ± 1.1				
ALL	283	-1.3 ± 1.2	137	-1.4 ± 1.2	146	-1.2 ± 1.3				
Mean (SD) Height for Age (HAZ): Primary school children (5-9.99 years)										
5-5.99	64	-0.9 ± 1.0	34	-0.9 ± 1.1	30	-0.9 ± 0.9				
6-6.99	59	-0.9 ± 1.1	29	-0.9 ± 1.1	30	-0.9 ± 1.0	Age group	4	0.552	n.s.
7-7.99	73	-1.0 ± 1.0	36	-1.3 ± 0.9	37	-0.7 ± 1.0	Sex	1	1.943	n.s.
8-8.99	60	-1.1 ± 1.0	22	-1.4 ± 0.9	38	-0.9 ± 0.9	Sex age int.	4	2.429	0.048
9-9.99	86	-1.1 ± 1.0	48	-1.0 ± 1.0	38	-1.2 ± 0.9				
ALL	342	-1.0 ± 1.0	169	-1.1 ± 1.0	173	-1.0 ± 1.0				
Mean (SD) Height for Age (HAZ):Adolescent (10-17.99 years)										
10-10.99	92	-1.2 ± 1.0	42	-1.0 ± 1.0	50	-1.3 ± 1.0				
11-11.99	68	-1.1 ± 1.0	28	-1.1 ± 0.7	40	-1.1 ± 1.2				
12-12.99	76	-1.7 ± 1.0	38	-1.8 ± 0.9	38	-1.6 ± 1.2	Age group	7	2.276	0.028
13-13.99	57	-1.4 ± 1.1	26	-1.4 ± 1.1	31	-1.5 ± 1.2	Sex	1	8.098	0.005
14-14.99	57	-1.5 ± 1.2	31	-1.7 ± 1.1	26	-1.2 ± 1.2	Sex age int.	7	3.659	0.001
15-15.99	46	-1.3 ± 1.2	18	-1.9 ± 1.2	28	-0.9 ± 1.0				
16-16.99	47	-1.5 ± 1.2	28	-2.0 ± 1.0	19	-0.8 ± 1.2				
17-17.99	24	-1.4 ± 1.1	11	-1.9 ± 1.4	13	-0.9 ± 0.6				
ALL	467	-1.4 ± 1.1	222	-1.5 ± 1.4	245	-1.2 ± 1.1				

Table 5.4.4: *ANOVA comparing mean HAZ by yearly age classes and gender for the pre-school, primary school and adolescent population by gender (Mar-95)*

Mean (SD) Weight for Height (WHZ): Pre-school and primary school children (<10 years)										
Age years	Total Pop. n	Total Pop. Mean SD	Males n	Males Mean SD	Females n	Females Mean SD	Main effect	df	F	p
0-4.99	281	-0.4 ± 1.0	136	-0.4 ± 1.0	169	-0.7 ± 0.7	Age group	1	7.117	0.008
5-9.99	340	-0.6 ± 0.8	145	-0.5 ± 1.0	171	-0.6 ± 0.8	Sex	1	0.000	n.s.
ALL	621	-0.5 ± 0.9	281	-0.4 ± 1.0	340	-0.6 ± 0.8	Sex age int.	1	1.166	n.s.

Table 5.4.5: *ANCOVA comparing mean WHZ by three discrete periods for the whole child population by gender*

Mean (SD) Weight for Height (WHZ): Pre-school children (0-4.99 years)										
Age mths	Total Pop. n	Total Pop. Mean SD	Males n	Males Mean SD	Females n	Females Mean SD	Main effect	df	F	p
0-11	54	-0.3 ± 1.3	28	-0.4 ± 1.1	26	-0.2 ± 1.2				
12-23	53	-0.7 ± 1.0	24	-0.5 ± 0.9	29	-0.8 ± 1.1	Age group	4	1.887	n.s.
24-35	42	-0.2 ± 1.0	21	-0.2 ± 1.0	21	-0.2 ± 1.2	Sex	1	0.313	n.s.
36-47	61	-0.3 ± 1.0	31	-0.3 ± 1.0	30	-0.4 ± 1.2	Sex age int.	4	0.424	n.s.
48-59	71	-0.5 ± 0.9	32	-0.5 ± 1.0	39	-0.6 ± 1.1				
ALL	281	-1.3 ± 1.2	136	-0.4 ± 1.0	145	-0.5 ± 1.3				
Mean (SD) Weight for Height (WHZ): Primary-school children (5-9.99 years)										
5-5.99	64	-0.5 ± 1.0	34	-0.5 ± 1.0	30	-0.5 ± 0.9				
6-6.99	58	-0.6 ± 0.7	29	-0.8 ± 0.7	29	-0.5 ± 1.0	Age group	4	0.827	n.s.
7-7.99	73	-0.7 ± 0.8	36	-0.7 ± 0.6	37	-0.7 ± 1.0	Sex	1	0.755	n.s.
8-8.99	60	-0.6 ± 0.8	22	-0.6 ± 0.8	38	-0.7 ± 0.9	Sex age int.	4	0.529	n.s.
9-9.99	85	-0.6 ± 0.6	48	-0.7 ± 0.6	37	-0.6 ± 0.9				
ALL	340	-0.6 ± 0.8	169	-0.7 ± 0.7	171	-0.6 ± 1.0				

Table 5.4.6: *ANCOVA comparing mean WHZ by yearly age classes and gender for the pre-school and primary school population by gender (Mar-95*

Mean (SD) Weight for Age (WAZ): Pre-school and primary school children (<10 years)										
Age years	Total Pop. n	Total Pop. Mean SD	Males n	Males Mean SD	Females n	Females Mean SD	Main effect	df	F	*p*
0-4.99	290	-1.1 ± 1.0	142	-1.1 ± 1.0	148	-1.2 ± 1.1	Age group	1	0.164	n.s.
5-9.99	347	-1.2 ± 0.8	172	-1.2 ± 0.9	175	-1.0 ± 0.8	Sex	1	0.633	n.s.
ALL	637	-1.1 ± 0.9	314	-1.2 ± 0.9	323	-1.1 ± 0.9	Sex age int.	1	2.414	n.s.

Table 5.4.7: *ANOVA comparing mean WAZ of pre-school and primary school children by gender*

Mean (SD) Weight for Age (WAZ): Pre-school children (0-4.99 years)										
Age mths	Total Pop. n	Total Pop. Mean SD	Males n	Males Mean SD	Females n	Females Mean SD	Main effect	df	F	*p*
0-11	59	-0.4 ± 1.2	32	-0.6 ± 1.1	27	-0.2 ± 1.3				
12-23	53	-1.5 ± 0.9	24	-1.4 ± 1.1	29	-1.6 ± 0.8	Age group	4	11.728	<0.001
24-35	43	-1.1 ± 0.9	22	-1.1 ± 1.0	21	-1.1 ± 0.9	Sex	1	0.023	n.s.
36-47	63	-1.2 ± 0.9	31	-1.0 ± 0.9	32	-1.5 ± 0.9	Sex age int.	4	1.775	n.s.
48-59	72	-1.4 ± 0.8	33	-1.5 ± 0.7	39	-1.3 ± 0.9				
ALL	290	-1.1 ± 1.0	142	-1.1 ± 1.0	148	-1.2 ± 1.1				
Mean (SD) Weight for Age (WAZ): Primary-school children (5-9.99 years)										
5-5.99	66	-0.9 ± 1.0	35	-1.0 ± 1.2	31	-0.9 ± 0.8				
6-6.99	58	-1.0 ± 0.9	29	-1.1 ± 1.0	29	-0.9 ± 0.9	Age group	4	1.438	n.s.
7-7.99	75	-1.1 ± 0.8	37	-1.4 ± 0.7	38	-0.9 ± 0.9	Sex	1	3.565	n.s.
8-8.99	62	-1.2 ± 0.8	23	-1.3 ± 0.8	39	-1.1 ± 0.8	Sex age int.	4	1.347	n.s.
9-9.99	86	-1.2 ± 0.6	48	-1.2 ± 0.7	38	-1.3 ± 0.6				
ALL	347	-1.1 ± 0.8	172	-1.2 ± 0.9	175	-1.0 ± 0.8				

Table 5.4.8: *ANOVA comparing mean WAZ by yearly age classes and gender for the pre-school and primary school population by gender*

Mean (SD) BMIZ : Male and Female children (0-17.99 years)								
		Males		Females				
Discrete Period of Childhood	Age (years)	n	BMIZ Mean SD	n	BMIZ Mean SD	DF	*t*	*p*
Pre-school	**0-4.99**	84	-0.2 ± 1.4	90	-0.4 ± 1.2	172	0.635	n.s.
Middle	**5-9.99**	169	-0.9 ± 1.0	172	-0.9 ± 1.0	339	-0.119	n.s.
Adolescence	**10-17.99**	222	-1.3 ± 0.9	244	-0.9 ± 1.0	464	-4.120	<0.001
ALL	**0-17.99**	475	-1.0 ± 1.1	506	-0.8 ± 1.0	979	-2.156	0.031

Table 5.4.9: *Results of independent t-test comparing gender difference mean BMIZ by the three distinct periods of childhood (Mar-95)*

Mean (SD) (BMIZ): Three discrete periods of childhood by gender and survey round										
Age	Total Pop.		Male		Female					
years	n	Mean SD	n	Mean SD	n	Mean SD	Main effect	df	F	*p*
2-4.99	172	-0.3 ± 1.3	84	-0.2 ± 1.4	90	-0.4 ± 1.2	Age group	2	38.850	<0.001
5-9.99	341	-0.9 ± 1.0	169	-0.9 ± 1.0	172	-0.9 ± 1.0	Sex	1	5.187	0.023
10-17.99	466	-1.1 ± 0.9	222	-1.3 ± 0.9	244	-0.9 ± 1.0	Sex age int.	2	4.557	0.011
ALL	981	-0.9 ± 1.1	475	-1.0 ± 1.1	506	-0.8 ± 1.0				

Table 5.4.10: *One-way ANOVA comparing mean BMIZ by three discrete periods for the whole child population by age group and gender (Mar-95)*

Mean (SD) BMI for Age (BMIZ): Pre-school children (0-4.99 years)										
Nov-94										
Age	Total Pop.		Males		Females					
months	n	Mean SD	n	Mean SD	n	Mean SD	Main effect	df	F	*p*
24-35	42	-0.01 ± 1.1	21	0.04 ± 1.2	21	-0.06 ± 1.1	Age group	2	2.648	n.s.
36-47	61	-0.2 ± 1.4	31	-0.2 ± 1.5	30	-0.3 ± 1.2	Sex	1	0.279	n.s.
48-59	71	-0.6 ± 1.2	32	-0.5 ± 1.4	39	-0.6 ± 1.1	Sex age int.	2	0.001	n.s.
ALL	174	-0.3 ± 1.3	84	-0.3 ± 1.4	90	-0.4 ± 1.2				
Mean (SD) BMI for Age (BMIZ): Primary school children (5-9.99 years)										
5-5.99	64	-0.7 ± 1.4	34	-0.7 ± 1.5	30	-0.7 ± 1.3				
6-6.99	58	-0.8 ± 0.9	29	-1.0 ± 1.0	29	-0.7 ± 0.8	Age group	4	1.115	n.s.
7-7.99	73	-1.0 ± 1.0	36	-1.0 ± 0.7	37	-1.1 ± 1.2	Sex	1	0.029	n.s.
8-8.99	60	-1.0 ± 1.0	22	-0.9 ± 1.1	38	-1.0 ± 0.9	Sex age int.	4	0.366	n.s.
9-9.99	86	-1.0 ± 0.7	48	-1.0 ± 0.7	38	-1.0 ± 0.7				
ALL	341	-0.9 ± 1.0	169	-0.9 ± 1.0	172	-0.9 ± 1.0				
Mean (SD) BMI for Age (BMIZ):Adolescent (10-17.99 years)										
10-10.99	92	-1.0 ± 0.7	42	-1.0 ± 0.6	50	-1.1 ± 0.8				
11-11.99	68	-1.1 ± 0.8	28	-1.4 ± 0.9	40	-0.9 ± 0.7				
12-12.99	76	-1.3 ± 0.8	38	-1.3 ± 0.7	38	-1.3 ± 0.8	Age group	7	2.892	0.006
13-13.99	57	-1.1 ± 1.1	26	-1.5 ± 0.9	31	-1.0 ± 1.2	Sex	1	17.430	<0.001
14-14.99	57	-1.3 ± 1.0	31	-1.3 ± 0.9	26	-1.1 ± 1.0	Sex age int.	7	4.088	<0.001
15-15.99	45	-0.8± 1.0	18	-1.5 ± 1.0	27	-0.3 ± 1.0				
16-16.99	47	-0.9 ± 1.2	28	-1.3 ± 1.1	19	-0.3 ± 1.1				
17-17.99	24	-0.7 ± 0.6	11	-0.8 ± 0.5	13	-0.6 ± 0.7				
ALL	466	-1.1 ± 0.9	222	-1.3 ± 0.9	244	-0.9 ± 1.0				

Table 5.4.11: *ANOVA comparing mean BMIZ by yearly age classes and gender for the pre-school, primary school and adolescent population by gender (Mar-95)*

Table 5.4.15: Logistic regression analyses for predicting child stunting (<-2 SD HA), underweight (<-2SD WA), wasting (<-2 SD WH) and thinness (<-2 SD BMIZ-for-age) using Age, Age², Age³ and Sex amongst pre-school children (0-4.99 years)				
Dependent variable	Independent variable	**B**	χ^2	***p***
Stunting	Constant Age Age² Age³ Sex	-2.9566 0.2179 -0.0069 0.0000698 -0.1031	12.988 4.4456 3.6222 3.4382 0.1438	 0.0350 0.0570 0.0637 n.s.
Percentage correctly predicted: <-2SD HA: 3.80 ≥-2 SD HA: 97.55 Overall model: 71.38%, χ^2=13.963; df=4; *p*=0.0074				
Underweight	Constant Age	-2.0014 0.0156	36.3794 3.2155	 0.0729
Percentage correctly predicted: <-2SD WA: 0.0 ≥-2 SD WA: 100.0 Overall model:81.729%; χ^2=3.301; df=1; *p*=0.0692				
Wasting	Constant Age	-1.7003 -0.0379	6.2932 17.8447	 0.0121
Percentage correctly predicted: <-2SD WH: 0.0 ≥-2 SD WH: 100.0 Overall model: 93.59%; χ^2=7.056; df=1; *p*=0.0079				
<-2 SD BMIZ for age	*No significant variables*			
MUAC <13.5	Constant Age Sex	-0.4946 -0.0480 0.8735	17.7423 5.3810 1.4701	 <0.001 0.0204
Percentage correctly predicted: <13.5:6.98 ≥13.5: 97.16 Overall model: 79.45%; χ^2=25.603; df=1; *p*<0.001				

Table 5.4.16: Logistic regression analyses to predicting child stunting (<-2 SD HA), underweight (<-2SD WA), wasting (<-2 SD WH) and thinness (<-2 SD BMIZ-for-age) using MUAC cut-off points for pre-school children (0-4.99 years)				
Dependent variable	Independent variable	**B**	χ^2	***p***
Stunting	Constant Age MUAC <14.0	-0.4991 0.0367 -0.9801	0.7450 12.6179 7.8059	 0.0004 0.0052
Percentage correctly predicted: <-2SD HA: 13.85 ≥-2 SD HA: 95.36 Overall model: 70.83%, χ^2=17.0008; df=1; *p*=0.0002				
Wasting				
Percentage correctly predicted: <-2SD HA: 13.85 ≥-2 SD HA: 95.36 Overall model: 70.83%, χ^2=17.0008; df=1; *p*=0.0002				
Underweight	Constant Age MUAC <13.5	-2.9629 0.0304 1.7321	30.3143 6.4163 15.6403	 0.0113 0.0001
Percentage correctly predicted: <-2SD WA: 14.63 ≥-2 SD WA: 98.86 Overall model: 82.95%, χ^2=17.937; df=2; *p*=0.001				
Underweight	Constant Age MUAC <14.0	1.0667 0.0427 -2.5753	2.9793 10.6584 32.7848	 0.0011 <0.001
Percentage correctly predicted: <-2SD WA: 34.15 ≥-2 SD WA: 95.45 Overall model:83.87%; χ^2=42.103; df=2; *p*=<0.001				

*NB: *only significant associations shown; **males=0, females=1*

Tables for section 5.5

Association between Stunting (<-2 HAZ) and gender by age group										
Nutrition Status	HAZ		Total Pop [a].		Pre-sch. [b]		Primary [c]		Adolescents [d]	
			M	F	M	F	M	F	M	F
Stunted	<-2	n	139	122	39	40	34	24	66	58
		%	(26.3)	(21.6)	(28.5)	(27.4)	(20.1)	(13.9)	(29.7)	(23.7)
Not stunted	≥-2	n	389	442	98	106	135	149	156	187
		%	(73.7)	(78.4)	(71.5)	(72.6)	(79.9)	(86.1)	(70.3)	(76.3)

Table 5.5.1: *Association between stunting <-2 HAZ and gender amongst whole child population (0-17.99 years) by age group (percentages in parentheses).*

a. χ^2=3.304; df=1; *n.s.* Male RR=1.22; Male OR=1.29
b. χ^2=0.040; df=1; *n.s.* Male RR=1.039; Male OR=1.055
c. χ^2=2.368; df=1; *n.s.* Male RR=1.450; Male OR=1.564
d. χ^2=2.190; df=1; *n.s.* Male RR=1.256; Male OR=1.364

Prevalence of Stunting (<-2 HAZ) by three discrete periods of childhood					
Discrete Period of Childhood	Age (years)	Stunted HAZ <-2SD		Adequate height for age HAZ ≥-2SD	
		n	%	n	%
Pre-school	0-4.99	79	27.9	204	72.1
Middle	5-9.99	58	17.0	284	83.0
Adolescence	10-17.99	124	26.6	343	73.4
ALL	0-17.99 years	261	23.9	831	76.1

Table 5.5.2: *Association between age group and stunting <-2 HAZ by three discrete periods of childhood (percentages in parentheses).* χ^2=13.374; df=2; p=0.001

Prevalence of Stunting (<-2 HAZ) amongst pre-school population by yearly age classes					
Discrete Period of Childhood	Age (months)	Stunted <-2 HAZ		Adequate height for age ≥-2 HAZ	
		n	%	n	%
Infants	0-11	6	10.9	49	89.1
1	12-23	17	32.1	36	67.9
2	24-35	11	26.2	31	73.8
3	36-47	16	26.2	45	73.8
4	48-59	29	40.3	43	59.7
All pre-schooler's	<60	79	27.9	204	72.1

Table 5.5.3: *Association between yearly age classes and stunting <-2 HAZ amongst pre-school children* χ^2=13.977; df=4; p=0.007.

Prevalence of Stunting (<-2 HAZ) amongst primary school-aged population by yearly age classes				
Age (years)	**Stunted** <-2 HAZ		**Adequate height for age** ≥-2 HAZ	
	n	%	n	%
5-5.99	11	17.2	53	18.7
6-6.99	10	16.9	49	17.3
7-7.99	8	11.0	65	22.9
8-8.99	12	20.0	48	16.9
9-9.99	17	19.8	69	20.2
<10	58	17.0	284	83.0

Table 5.5.4: *Association between yearly age classes and stunting <-2 HAZ amongst primary school-aged children* χ^2=2.744; df=4; n.s.

Prevalence rate (%) of Stunting (<-2 HAZ) amongst male and female adolescents by yearly age classes						
	All adolescents [a]		**Males** [b]		**Females** [c]	
	<-2 HAZ	**≥-2 HAZ**	**<-2 HAZ**	**≥-2 HAZ**	**<-2 HAZ**	**≥-2 HAZ**
10-10.99	19.6	80.4	11.9	88.1	26.0	74.0
11-11.99	11.8	88.2	0.0	100.0	20.0	80.0
12-12.99	38.2	61.8	36.8	63.2	39.5	60.5
13-13.99	24.6	75.4	19.2	80.8	29.0	71.0
14-14.99	38.6	61.4	51.6	48.4	23.1	76.9
15-15.99	30.4	69.6	50.0	50.0	17.9	82.1
16-16.99	12.9	66.0	50.0	50.0	10.5	89.5
17-17.99	12.5	87.5	27.3	72.7	0.0	100.0
	26.6	73.4	29.7	70.3	23.7	76.3

Table 5.5.5: *Association between yearly age classes and stunting <-2 HAZ amongst male and female adolescents.*

a. *All adolescents:* χ^2=23.670, df=7; p=0.001

b. *Males:* χ^2=36.711, df=7; p<0.001

c. Females: χ^2=12.570, df=7; n.s.

Degrees of shortness by gender for the whole child population							
Degree of shortness	**HAZ**	**Total Child Pop.**		**Males**		**Females**	
		n	**%**	**n**	**%**	**n**	**%**
Adequate height for age	≥-1	439	40.2	186	35.2	253	44.9
Mild stunting	≥-2 to <-1	392	35.9	203	38.4	189	33.5
Moderate stunting	≥-3 to <-2	206	18.9	11	21.0	95	16.8
Severe stunting	<-3	55	5.0	28	5.3	27	4.8

Table 5.5.6: *Association between degrees of shortness and gender within the child population in Mar-95.* χ^2=10.811 df=3; p=0.013

Degrees of shortness by gender and age group for child population										
Degree of shortness	HAZ	Pre-school [a]			Primary [b]			Adolescents [c]		
		All	M	F	All	M	F	All	M	F
Adequate height for age	≥-1	39.6	36.5	42.5	49.4	46.2	52.6	33.8	26.1	40.8
Mild stunting	≥-2 to <-1	32.5	35.0	30.2	33.6	33.7	33.5	39.6	44.1	35.5
Moderate stunting	≥-3 to <-2	21.9	23.4	20.5	14.9	17.8	12.1	19.9	22.1	18.0
Severe stunting	<-3	6.0	5.1	6.8	2.0	2.4	1.7	6.6	7.7	5.7

Table 5.5.7: *Association between degrees of shortness and gender by discrete periods of childhood (Mar-95).*

a. Pre-school population: χ^2=1.769 df=3; n.s.

b. Primary school-aged population: χ^2=2.693 df=3; n.s. c. *Adolescent:* χ^2=11.272 df=3; p=0.010

Degrees of shortness by age group for the whole child population							
Degree of shortness	HAZ	Pre-school [a]		Primary [b]		Adolescents [c]	
		n	%	n	%	n	%
Adequate height for age	≥-1	112	39.6	169	49.4	158	33.8
Mild stunting	≥-2 to <-1	92	32.5	115	33.6	185	39.6
Moderate stunting	≥-3 to <-2	62	21.9	51	14.9	93	19.9
Severe stunting	<-3	17	6.0	7	2.0	31	6.6

Table 5.5.8: *Association between degrees of shortness and age group (Mar-95).*

a. χ^2=28.627, df=6; p<0.001

Comparison of the physiological characteristics of stunted and non-stunted pre-school children								
	Stunted n=79		**Adequate HA n=204**					
	Mean	**SD**	**Mean**	**SD**	**Main effect**	**df**	**t**	***p***
Age (mths)	36.4	16.7	29.0	18.0	Stunting	281	3.166	0.002
					Main effect	**df**	**F**	***p***
Weight (kg)	10.4	1.3	11.7	1.2	Age	1	1511.3	<0.001
					Age^2	1	47.237	<0.001
					Stunting	1	61.720	<0.001
MUAC	14.2	1.2	14.6	1.2	Age	1	29.699	<0.001
					Age^2	1	11.805	0.001
					Stunting	1	6.210	0.013
BMI	16.0	1.6	15.6	1.6	Age	1	15.868	<0.001
					Age^2	1	15.645	<0.001
					Stunting	1	4.386	0.037
BMIZ	0.03	1.2	-0.46	1.2	Age	1	5.019	0.026
					Stunting	1	5.827	0.017
WHZ	-0.33	1.0	-0.48	1.0	Age	1	0.138	n.s.
					Age^2	1	0.550	n.s.
					Age^3	1	3.867	0.050
					Stunting	1	1.157	n.s.
WAZ	-1.85	0.9	-0.88	0.9	Age	1	24.903	<0.001
					Age^2	1	8.144	0.005
					Age^3	1	17.889	<0.001
					Stunting	1	70.340	<0.001

Table 5.5.9*: Physiological characteristics of stunted and non-stunted pre-school children*

The physiological characteristics of stunted and non-stunted primary school -aged children								
	Stunted n=58		**Adequate HA n=283**					
	Mean	**SD**	**Mean**	**SD**	**Main effect**	**df**	**t**	***p***
Age (yrs)	7.6	1.5	7.5	1.4	Stunting	339	0.340	n.s.
					Main effect	**df**	**F**	***p***
Weight (kg)	18.0	2.3	21.3	2.3	Age	1	471.45	<0.001
					Stunting	1	101.34	<0.001
MUAC	15.0	1.0	15.8	1.0	Age	1	76.394	<0.001
					Stunting	1	29.270	<0.001
BMI	14.6	1.1	14.7	1.1	Age	1	2.190	n.s.
					Age^2	1	5.475	0.020
					Stunting	1	0.135	n.s.
BMIZ	-0.93	1.0	-0.91	1.0	Age	1	3.169	n.s.
					Stunting	1	0.013	n.s.
WHZ	-0.58	0.8	-0.64	0.8	Age	1	0.894	n.s.
					Stunting	1	0.255	n.s.
WAZ	-2.01	0.7	-0.93	0.7	Age	1	6.710	0.010
					Stunting	1	115.57	<0.001

Table 5.5.10*: Physiological characteristics of stunted and non-stunted primary school-aged children*

The physiological characteristics of stunted and non-stunted adolescents								
	Stunted n=124		Adequate HA n=342					
	Mean	**SD**	**Mean**	**SD**	**Main effect**	**df**	**t**	***p***
Age (yrs)	13.5	2.0	13.1	2.3	Stunting	464	1.609	n.s.
					Main effect	**df**	**F**	***p***
Weight (kg)	30.5	5.7	38.5	5.7	Age	1	936.5	<0.001
					Age^2	1	7.186	0.008
					Stunting	1	175.59	<0.001
MUAC	18.2	1.9	20.0	1.8	Age	1	572.87	<0.001
					Age^2	1	15.296	<0.001
					Stunting	1	74.697	<0.001
BMI	15.9	1.7	17.0	1.7	Age	1	340.98	<0.001
					Age^2	1	13.497	<0.001
					Stunting	1	36.729	<0.01
BMIZ	-1.53	0.9	-0.94	0.9	Age	1	4.794	0.029
					Age^2	1	14.057	<0.001
					Stunting	1	40.577	<0.001

Table 5.5.11: *Physiological characteristics of stunted and non-stunted adolescents*

Association between Wasting (<-2 WHZ) and gender by age group							
Nutrition Status		Total Pop [a]. M	F	Pre-sch. [b] M	F	Primary [c] M	F
Wasted <-2 WHZ	n	13	18	7	11	6	7
	%	4.3	5.7	5.1	7.6	3.6	4.1
Adequate weight for height ≥-2 WHZ	n	292	298	129	134	163	164
	%	95.7	94.3	94.9	92.4	96.4	95.9

Table 5.5.12: *Association between gender and wasting <-2 WHZ amongst whole child population (<10 years) by age group(percentages in parentheses).*

a. χ^2=0.673; df=1; *n.s.* b. χ^2=0.696; df=1; *n.s.* c. χ^2=0.068; df=1; *n.s.*

Prevalence of Wasting (<-2 WHZ) by three discrete periods of childhood					
Discrete Period of Childhood	Age (years)	Wasting <-2 WHZ		Adequate weight for height ≥ -2 WHZ	
		n	%	n	%
Pre-school	0-4.99	18	6.4	263	93.6
Middle	5-9.99	13	3.8	327	96.2
ALL	<10 years	31	5.0	590	95.0

Table 5.5.13: *Association between age group and wasting <-2 WHZ by two periods of childhood (percentages in parentheses).* χ^2=2.163; df=1; n.s.

Prevalence of Wasting (<-2 WHZ) amongst pre-school population by yearly age classes					
Discrete Period of Childhood	Age (mths)	Wasted <-2 WHZ		Adequate weight for height ≥ -2 WHZ	
Pre-school (yrs)[a]		n	%	n	%
Infants	0-11	6	11.1	48	88.9
1-1.99	12-23	6	11.3	47	88.7
2-2.99	24-35	2	4.8	40	95.2
3-3.99	36-47	2	3.3	59	96.7
4-4.99	48-59	2	2.8	69	97.2
<5	<60	18	6.4	263	93.6
Prevalence of Wasting (<-2 WHZ) amongst primary school-aged population by yearly age classes					
Discrete Period of Childhood	Age (mths)	Wasted <-2 WHZ		Adequate weight for height ≥ -2 WHZ	
Primary school-aged (yrs) [a]		n	%	n	%
5-5.99	60-71	5	7.8	59	92.2
6-6.99	72-83	1	1.7	57	98.3
7-7.99	84-95	1	1.4	72	98.6
8-8.99	96-107	3	5.0	57	95.0
9-9.99	108-119	3	3.5	82	96.5
<10	≥60-<120	13	3.8	327	96.2

Table 5.5.14: *Association between yearly age classes and wasting <-2 WHZ amongst pre-school and primary school-aged children*

a. χ^2=6.839; df=4; n.s. b. χ^2=4.905; df=4; n.s.

Degrees of wasting by gender and age group for child population <10 years										
Degree of wasting	WHZ	Total Pop.[a]			Pre-school[b]			Primary school-aged[c]		
		All	M	F	All	M	F	All	M	F
Adequate weight for height	≥-1	69.6	68.9	70.3	71.2	72.1	70.3	68.2	66.3	70.2
Mild wasting	≥-2 to <-1	25.4	26.9	24.1	22.4	22.8	22.1	27.9	30.2	25.7
Moderate wasting	≥-3 to <-2	4.5	3.6	5.4	5.7	3.7	7.6	3.5	3.6	3.5
Severe wasting	<-3	0.5	0.7	0.3	0.7	1.5	0.0	0.3	0.0	0.6

Table 5.5.15: *Association between degrees of wasting and gender by two discrete periods of childhood (Mar-95).*

a. Total Population <10 years: (n=621) χ^2=1.986, df=3; n.s.
b. Pre-school population: (n=281) χ^2=4.062, df=3; n.s.
c. Primary school-aged population (n=340): χ^2=1.780, df=3; n.s.

Degrees of wasting by age group for child population <10 years[a]							
Degree of wasting	WHZ	Total Pop.		Pre-school		Primary school-aged	
		n	%	n	%	n	%
Adequate weight for height	≥-1	432	69.6	200	71.2	232	68.2
Mild wasting	≥-2 to <-1	158	25.4	63	22.4	95	27.9
Moderate wasting	≥-3 to <-2	28	4.5	16	5.7	12	3.5
Severe wasting	<-3	3	0.5	2	0.7	1	0.3

Table 5.5.16: *Association between degrees of wasting by two discrete periods of childhood (Mar-95).*

a. χ^2=4.188, df=3; n.s.

Association between underweight (<-2 WAZ) and gender by age group							
Nutrition Status		**Total Pop [a].**		**Pre-sch. [b]**		**Primary [c]**	
		M	**F**	**M**	**F**	**M**	**F**
Underweight <-2 WAZ	n	50	49	22	31	28	18
	%	15.9	15.2	15.5	20.9	16.3	10.3
Adequate weight for age ≥-2 WAZ	n	264	274	120	117	144	157
	%	84.1	84.8	84.5	79.1	83.7	89.7

Table 5.5.17: *Association between gender and underweight <-2 WAZ amongst whole child population (<10 years) by age group(percentages in parentheses).*

a. χ^2=0.069; df=1; *n.s.* b. χ^2=1.443; df=1; *n.s.* c. χ^2=2.710; df=1; *n.s.*

Prevalence of Underweight (<-2 WAZ) by two discrete periods of childhood					
Discrete Period of Childhood	**Age (years)**	**Underweight <-2 WAZ**		**Adequate weight for age ≥-2 WAZ**	
		n	%	n	%
Pre-school	**0-4.99**	53	18.8	237	81.7
Middle	**5-9.99**	46	13.3	301	86.7
ALL	**<10 years**	99	15.5	538	84.5

Table 5.5.18: *Association between age group and underweight <-2 WAZ by two periods of childhood (percentages in parentheses).* χ^2=3.032; df=1; n.s.

Prevalence of Underweight (<-2 WAZ) amongst pre-school population by yearly age classes					
Discrete Period of Childhood	**Age (mths)**	**Underweight <-2 WAZ**		**Adequate weight for age ≥-2 WAZ**	
Pre-school (yrs)[a]		**n**	**%**	**n**	**%**
Infants	**0-11**	5	8.5	54	91.5
1-1.99	**12-23**	12	22.6	41	77.4
2-2.99	**24-35**	7	16.3	36	83.7
3-3.99	**36-47**	13	20.6	50	79.4
4-4.99	**48-59**	16	22.2	56	77.8
<5	**<60**	53	18.3	237	81.7
Prevalence of Underweight (<-2 WAZ) amongst primary school -aged population by yearly age classes					
Discrete Period of Childhood	**Age (mths)**	**Underweight <-2 WAZ**		**Adequate weight for age ≥-2 WAZ**	
Primary school-aged (yrs) [a]		**n**	**%**	**n**	**%**
5-5.99	**60-71**	10	15.2	56	84.8
6-6.99	**72-83**	10	17.2	48	82.8
7-7.99	**84-95**	8	10.7	67	89.3
8-8.99	**96-107**	10	16.1	52	83.9
9-9.99	**108-119**	8	9.3	78	90.7
<10	**≥60-<120**	46	13.3	301	86.7

Table 5.5.19: *Association between yearly age classes and underweight <-2 WAZ amongst pre-school and primary school-aged children*

a. χ^2=5.571; df=4; n.s. b. χ^2=3.059; df=4; n.s.

Degrees of underweight by gender and age group for child population <10 years										
Degree of underweight	WAZ	Total Pop. [a]			Pre-school [b]			Primary school-aged [c]		
		All	M	F	All	M	F	All	M	F
Adequate weight for age	≥-1	41.1	40.8	41.5	40.7	43.0	38.5	41.5	39.0	44.0
Mild underweight	≥-2 to <-1	43.3	43.3	43.3	41.0	41.5	40.5	45.2	44.8	45.7
Moderate underweight	≥-3 to <-2	14.0	14.3	13.6	15.5	13.4	17.6	12.7	15.1	10.3
Severe underweight	<-3	1.6	1.6	1.5	2.8	2.1	3.4	0.6	1.2	0.0

Table 5.5.20: *Association between degrees of underweight and gender by two discrete periods of childhood (Mar-95).*

a. Total Population <10 years: (n=637) χ^2=0.079, df=3; n.s.

b. Pre-school population: (n=290) χ^2=1.609, df=3; n.s.

c. Primary school-aged population (n=347): χ^2=4.181, df=3; n.s.

Degrees of underweight by age group for child population <10 years [a]							
Degree of underweight	WAZ	Total Pop.		Pre-school		Primary school-aged	
		n	%	n	%	n	%
Adequate weight for age	≥-1	262	41.1	118	40.7	114	41.5
Mild underweight	≥-2 to <-1	276	43.3	119	41.0	157	45.2
Moderate underweight	≥-3 to <-2	89	14.0	45	15.5	44	12.7
Severe underweight	<-3	10	1.6	8	2.8	2	0.6

Table 5.5.21: *Association between degrees of wasting by two discrete periods of childhood (Mar-95).*

χ^2=6.374, df=3; n.s.

Nutritional status profile of whole population (<10 years) by gender							
		Total Pop.		Males		Females	
		Wasting WHZ		Wasting WHZ		Wasting WHZ	
		<-2	≥-2	<-2	≥-2	<-2	≥-2
Stunting	**<-2**	0.6 *Wasted & Stunted*	21.4 *Stunted*	1.0 *Wasted & Stunted*	23.0 *Stunted*	0.3 *Wasted & Stunted*	19.9 *Stunted*
HAZ	**≥-2**	4.3 *Wasted*	73.6 *Normal*	3.3 *Wasted*	72.8 *Normal*	5.4 *Wasted*	74.4 *Normal*

***Table 5.5.22**: Association between Waterlow's classification of nutritional status and gender for the primary school-aged population*
χ^2=3.359, df=3; n.s.

Nutritional status profile of whole population (<10 years) by age group							
		Total Pop.		Pre-school children		Primary school children	
		Wasting WHZ		Wasting WHZ		Wasting WHZ	
		<-2	≥-2	<-2	≥-2	<-2	≥-2
Stunting	**<-2**	0.6 *Wasted & Stunted*	21.4 *Stunted*	1.4 *Wasted & Stunted*	26.7 *Stunted*	0.0 *Wasted & Stunted*	17.1 *Stunted*
HAZ	**≥-2**	4.3 *Wasted*	73.6 *Normal*	5.0 *Wasted*	66.9 *Normal*	3.8 *Wasted*	79.1 *Normal*

***Table 5.5.23:** Association between Waterlow's classification of nutritional status and age groups for the total child population <10 years*
χ^2=15.097, df=3; p=0.002

Nutritional status profile of pre-school children (0-4.99 years)							
		Total Pop.		**Males**		**Females**	
		Wasting WHZ		**Wasting WHZ**		**Wasting WHZ**	
		<-2	≥-2	<-2	≥-2	<-2	≥-2
Stunting	**<-2**	1.4 *Wasted & Stunted*	26.7 *Stunted*	2.2 *Wasted & Stunted*	26.5 *Stunted*	0.7 *Wasted & Stunted*	26.9 *Stunted*
HAZ	**≥-2**	5.0 *Wasted*	66.9 *Normal*	2.9 *Wasted*	68.4 *Normal*	6.9 *Wasted*	65.5 *Normal*

Table 5.5.24: *Association between Waterlow's classification of nutritional status and gender for pre-school population*
χ^2=3.428, df=3; n.s.

Nutritional status profile of pre-school population (0-4.99 years) by yearly age classes				
	Waterlow's classification			
	WHZ <-2 & HAZ <-2	**WHZ <-2 HAZ ≥-2**	**WHZ ≥-2 HAZ <-2**	**WHZ ≥-2 HAZ ≥-2**
Age (years)	*Wasted & Stunted*	*Wasted*	*Stunted*	*Adequately nourished*
<1 year	0.0	11.1	11.1	77.8
1-1.99	3.8	7.5	28.3	60.4
2-2.99	0.0	4.8	26.2	69.0
3-3.99	0.0	3.3	26.2	70.5
4-4.99	2.8	0.0	38.0	59.2

Table 5.5.25: *Association between Waterlow's classification of nutritional status and yearly age classes for pre-school population*
χ^2=24.393, df=12; p=0.018

Nutritional status profile of primary school-aged population (5-9.99 years) by gender							
		Total Pop.		**Males**		**Females**	
		Wasting WHZ		**Wasting WHZ**		**Wasting WHZ**	
		<-2	≥-2	<-2	≥-2	<-2	≥-2
Stunting	**<-2**	0.0 *Wasted & Stunted*	17.1 *Stunted*	0.0 *Wasted & Stunted*	20.1 *Stunted*	0.0 *Wasted & Stunted*	14.0 *Stunted*
HAZ	**≥-2**	3.8 *Wasted*	79.1 *Normal*	3.6 *Wasted*	76.3 *Normal*	4.1 *Wasted*	81.9 *Normal*

Table 5.5.26: *Association between Waterlow's classification of nutritional status and gender for the primary school-aged population* χ^2=2.239, df=3; n.s.

Nutritional status profile of primary school-aged population (5-9.99 years) by yearly age classes				
	Waterlow's classification			
	WHZ <-2 & HAZ <-2	**WHZ <-2 HAZ ≥-2**	**WHZ ≥-2 HAZ <-2**	**WHZ ≥-2 HAZ ≥-2**
Age (years)	*Wasted & Stunted*	*Wasted*	*Stunted*	*Adequately nourished*
5-5.99	0.0	7.8	17.2	75.0
6-8.99	0.0	1.7	17.2	81.0
7-7.99	0.0	1.4	11.0	87.7
8-8.99	0.0	5.0	20.0	75.0
9-9.99	0.0	3.5	20.0	76.5

Table 5.5.27: *Association between Waterlow's classification of nutritional status and yearly age classes for primary school-aged population* χ^2=8.090, df=8; n.s.

		Wasting (Weight for Height)			
		<-2 SD	≥-2 SD to -1SD	≥- 1 SD	TOTAL
Stunting	**<-2 SD**	0.6 *1.0* *0.3* *Very short for age* *Very thin*	5.0 *5.9* *4.1* *Very short for age* *Thin*	16.4 *17.0* *15.8* *Very short for age* *Adequate weight for height*	**22.0** ***23.9*** ***20.2***
Height for age	**≥-2 SD to <-1 SD**	2.1 *1.6* *2.5* *Short for age* *Very thin*	7.6 *8.9* *6.3* *Short for age* *Thin*	23.7 *23.9* *23.4* *Short for age* *Adequate weight for height*	**33.4** ***34.4*** ***32.2***
	≥- 1 SD	2.3 *1.6* *2.8* *Adequate height for age* *Very thin*	12.9 *12.1* *13.6* *Thin* *Normal height*	29.5 *27.9* *31.0* *Adequate height for age* *Adequate weight for height*	**44.7** ***41.6*** ***47.4***
	TOTAL	**5.0** ***4.2*** ***5.6***	**25.5** ***26.9*** ***24.0***	**69.6** ***68.8*** ***70.2***	**100.0**

Table 5.5.28: *Modification of Waterlow's classification used to discriminate between mild and moderate wasting and stunting amongst males (blue italics) and females (red italics) in Mar-95* χ^2=5.911, df=8; *n.s.*

		Wasting (Weight for Height)			
		<-2 SD	≥-2 SD to -1SD	≥- 1 SD	TOTAL
Stunting	<-2 SD	0.6 *1.4* *0.0* *Very short for age* *Very thin*	5.0 *4.6* *5.3* *Very short for age* *Thin*	16.4 *22.1* *11.8* *Very short for age* *Adequate weight for height*	**22.0** ***28.1*** ***17.1***
Height for age	≥-2 SD to <-1 SD	2.1 *2.1* *2.1* *Short for age* *Very thin*	7.6 *6.0* *8.8* *Short for age* *Thin*	23.7 *24.6* *22.9* *Short for age* *Adequate weight for height*	**33.4** ***32.7*** ***33.8***
	≥- 1 SD	2.3 *2.8* *1.8* *Adequate height for age* *Very thin*	12.9 *11.7* *13.8* *Thin* *Normal height*	29.5 *24.6* *33.5* *Adequate height for age* *Adequate weight for height*	**44.7** ***39.1*** ***49.1***
	TOTAL	**5.0** ***6.3*** ***3.9***	**25.5** ***22.3*** ***27.9***	**69.6** ***71.3*** ***68.2***	**100.0**

Table 5.5.29: *Modification of Waterlow's classification used to discriminate between mild and moderate wasting and stunting amongst pre-school (red italics) and primary school population (black italics) in Mar-95* χ^2=22.171, df=8; p=0.005

Association between Thinness (BMIZ <-2SD) and gender by age group									
Nutrition Status		**Total Pop [a].**		**Pre-sch. [b]**		**Primary [c]**		**Adolescents [d]**	
		M	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Thinness <-2 BMIZ	n	70	58	9	4	21	20	40	34
	%	14.7	11.5	10.7	4.4	12.4	11.6	18.0	13.9
Adequate weight for height ≥-2 BMIZ	n	405	448	75	86	148	152	182	210
	%	85.3	88.5	89.3	95.6	87.6	88.4	82.0	86.1

Table 5.5.30: *Association between thinness BMIZ <-2 SD and gender amongst whole child population (0-17.99 years) by age group*

a. χ^2=2.315; df=1; n.s. b. χ^2=2.471; df=1; n.s.
b. χ^2=0.051; df=1; n.s. d. χ^2=1.451; df=1; n.s.

Prevalence of Stunting (<-2 BMIZ) by three discrete periods of childhood					
Discrete Period of Childhood	**Age (years)**	**Thinness** <-2 BMIZ		**Adequate weight for height** ≥-2 BMIZ	
		n	%	n	%
Pre-school	**0-4.99**	13	7.5	161	92.5
Middle	**5-9.99**	41	12.0	300	88.0
Adolescence	**10-17.99**	74	15.9	392	84.1
ALL	**0-17.99 years**	128	13.0	853	87.0

Table 5.5.31: *Association between age group and thinness <-2 BMIZ by three discrete periods of childhood.* χ^2=8.379; df=2; p=0.015

Prevalence of Thinness (<-2 BMIZ) amongst pre-school population by yearly age classes [a]				
Discrete Period of Childhood	**Thinness** <-2 BMIZ		**Adequate weight for height** ≥-2 BMIZ	
	n	%	n	%
2-2.99	3	7.1	39	92.9
3-3.99	4	6.6	57	93.4
4-4.99	6	8.5	65	91.5
Prevalence of Thinness (<-2 BMIZ) amongst primary school-aged Pop. by yearly age classes [b]				
5-5.99	9	14.1	55	85.9
6-6.99	6	10.3	52	89.7
7-7.99	10	13.7	63	86.3
8-8.99	8	13.3	52	86.7
9-9.99	8	9.3	78	90.7
Prevalence of Thinness (<-2 BMIZ) amongst adolescents by yearly age classes [c]				
10-10.99	9	9.8	83	90.2
11-11.99	9	13.2	59	86.8
12-12.99	17	22.4	59	77.6
13-13.99	11	19.3	46	80.7
14-14.99	14	24.6	43	75.4
15-15.99	6	13.3	39	86.7
16-16.99	8	17.0	39	83.0
17-17.99	0	0.0	24	100.0

Table 5.5.32: *Association between thinness <-2 BMIZ and age by yearly age classes*

a. χ^2=0.179; df=2 ; n.s. b. χ^2=1.299; df=4 ; n.s. c. χ^2=13.821; df=7; p=0.054

Degrees of thinness by gender for the whole child population							
Degree of thinness	BMIZ	Total Child Pop.		Males		Females	
		n	%	n	%	n	%
Adequate weight for height	≥-1	563	57.4	256	53.9	307	60.7
Mild thinness	≥-2 to <-1	290	29.6	149	31.4	141	27.9
Moderate thinness	≥-3 to <-2	99	10.1	54	11.4	45	8.9
Severe thinness	<-3	29	3.0	16	3.4	13	2.6

Table 5.5.33: *Association between degrees of thinness and gender within the child population in Mar-95.* χ^2=4.994, df=3; n.s.

Degrees of thinness by gender and age group for child population										
	BMIZ	Pre-school [a]			Primary [b]			Adolescents [c]		
		All	M	F	All	M	F	All	M	F
Adequate weight for height	≥-1	76.4	76.2	76.7	60.4	60.9	59.9	48.1	40.1	55.3
Mild thinness	≥-2 to <-1	16.1	13.1	18.9	27.9	26.6	28.5	36.1	41.9	30.7
Moderate thinness	≥-3 to <-2	4.6	7.1	2.2	9.1	9.5	8.7	12.9	14.4	11.5
Severe thinness	<-3	2.9	3.6	2.2	2.9	3.0	2.9	3.0	3.6	2.5

Table 5.5.34: *Association between degrees of thinness and gender by discrete periods of childhood (Mar-95).*

a. Pre-school population: χ^2=3.471, df=3, n.s. *Primary school-aged population:* χ^2=0.176, df=3, n.s.

b. Adolescent: χ^2=10.913, df=3, p=0.012

Degrees of thinness by gender and age group for child population							
Degree of shortness	BMIZ	Pre-school [a]		Primary [b]		Adolescents [c]	
		n	%	n	%	n	%
Adequate weight for height	≥-1	133	76.4	206	60.4	224	48.1
Mild thinness	≥-2 to <-1	28	16.1	94	27.6	168	36.1
Moderate thinness	≥-3 to <-2	8	4.6	31	9.1	60	12.9
Severe thinness	<-3	5	2.9	10	2.9	14	3.0

Table 5.5.35: *Association between degrees of thinness and age group (Mar-95).*

χ^2=45.504, df=6; p<0.001

Prevalence of Adult Chronic Energy Deficiency by gender							
Nutritional status classification	**BMI kg/m²**	**Total Pop.**		**Males**		**Females**	
		n	**%**	**n**	**%**	**n**	**%**
CED	<18.5	57	10.6	41	19.2	16	5.0
Adequate nourishment	≥18.5	479	89.4	172	80.8	307	95.0

Table 5.5.42: *Number and percentage prevalence rate of chronic energy deficiency (CED) BMI <18.5 amongst adult population ≥18 years old by gender*
χ^2=27.376; df=1; p=<0.001 RR=1.996; OR=4.547

Degrees of adult under and over-nourishment by gender							
Nutritional status classification	**BMI kg/m²**	**Total Pop.**		**Males (n=214)**		**Females (n=323)**	
		n	**%**	**n**	**%**	**n**	**%**
Severe underweight	<16.0	4	0.7	3	1.4	1	0.3
Moderate underweight	16.0-16.99	9	1.7	5	2.3	4	1.2
Mild underweight	17.0-18.49	44	8.2	33	15.4	11	3.4
Adequate weight	18.5-24.99	382	71.1	166	77.6	216	66.9
Overweight Grade I	25.0-29.99	70	13.0	6	2.8	64	19.8
Obese Grade II	30.0-39.99	25	4.7	1	0.5	24	7.4
Obese Grade III	≥40	3	0.6	0	0.0	3	0.9

Table 5.5.43: *Association between degrees of underweight & overweight and gender within the adult (≥18 years) population in Mar-95.* χ^2=71.702 df=6; p=<0.001

Degrees of male adult under and over-nourishment by age group							
Nutritional status classification	**BMI kg/m²**	**Young adults**		**Middle-aged**		**Elderly**	
		n	**%**	**n**	**%**	**n**	**%**
Severe underweight	<16.0	1	2.6	0	0.0	2	4.0
Moderate underweight	16.0-16.99	0	0.0	4	3.2	1	2.0
Mild underweight	17.0-18.49	4	10.3	18	14.5	11	22.0
Adequate weight	18.5-24.99	34	87.2	99	79.8	33	66.0
Overweight Grade I	25.0-29.99	0	0.0	3	2.4	3	6.0
Obese Grade II	30.0-39.99	0	0.0	0	0.0	0	0.0
Obese Grade III	≥40	0	0.0	0	0.0	0	0.0

Table 5.5.44: *Association between degrees of underweight & overweight and age within the male adult (≥18 years) population in Mar-95.* χ^2=12..348 df=8; *n.s.*

Degrees of female adult under and over-nourishment by age group							
Nutritional status classification	**BMI kg/m²**	**Young adults**		**Middle-aged**		**Elderly**	
		n	**%**	**n**	**%**	**n**	**%**
Severe underweight	<16.0	0	0.0	0	0.0	1	2.0
Moderate underweight	16.0-16.99	0	0.0	0	0.0	4	8.0
Mild underweight	17.0-18.49	2	4.2	5	2.2	4	8.0
Adequate weight	18.5-24.99	42	87.5	144	64.0	30	60.0
Overweight Grade I	25.0-29.99	4	8.3	54	24.0	6	12.0
Obese Grade II	30.0-39.99	0	0.0	20	8.9	4	8.0
Obese Grade III	≥40	0	0.0	2	0.9	1	2.0

Table 5.5.45: *Association between degrees of underweight & overweight and age within the female adult (≥18 years) population in Mar-95.* χ^2=47.114, df=12; p<0.001

Figures for section 5.3

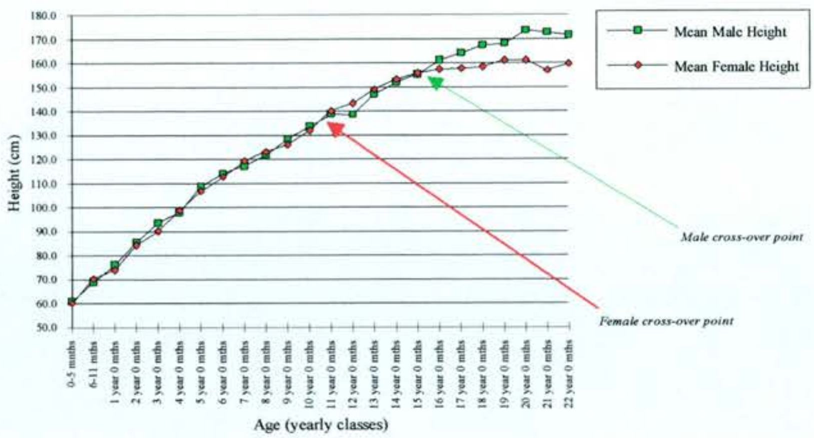

Figure 5.2: *Mean attained height (cm) of male and female children by yearly age classes for Buhera child population aged between 0-21 years measured in Mar-95.*

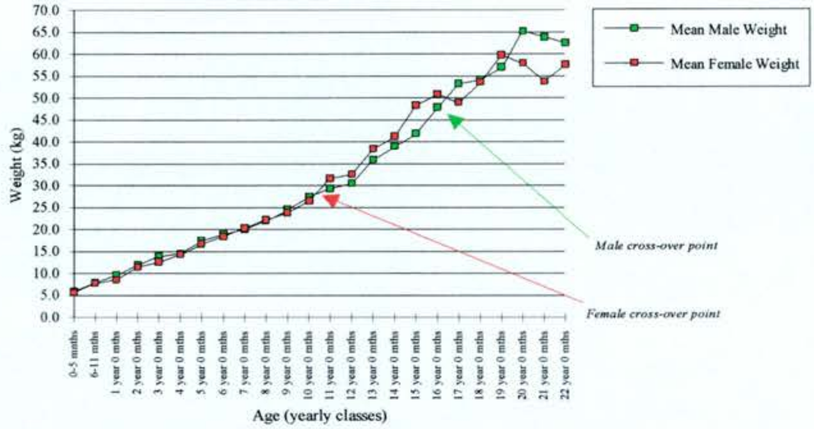

Figure 5.3: *Mean weight (kg) of male and female children by yearly age classes for Buhera child population aged between 0-21years measured in Mar-95*

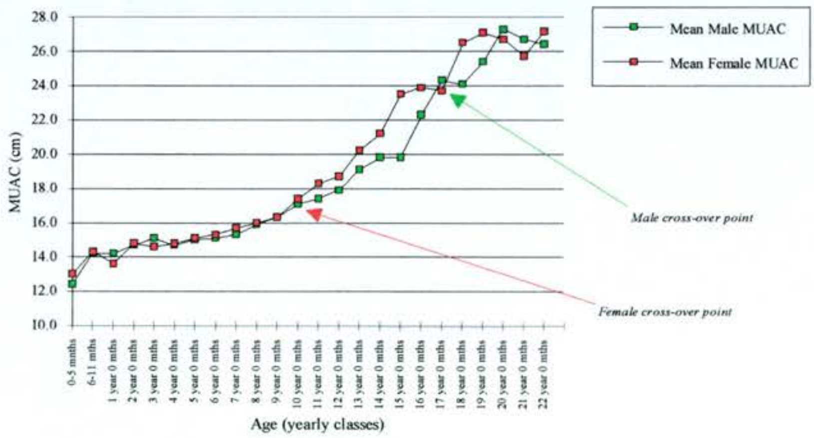

Figure 5.4: *Mean MUAC (cm) of male and female children by yearly age classes for Buhera child population aged between 0-21 years measured in Mar-95*

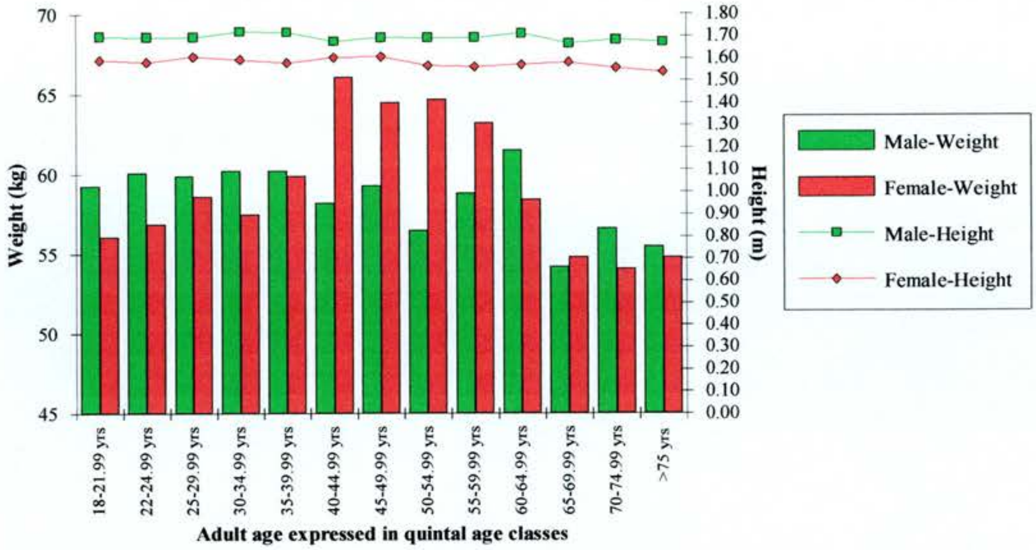

Figure 5.5: *Mean height (m) and weight (kg) of male and female adult ≥18 years population by quintal age classes measured in Mar-95.*

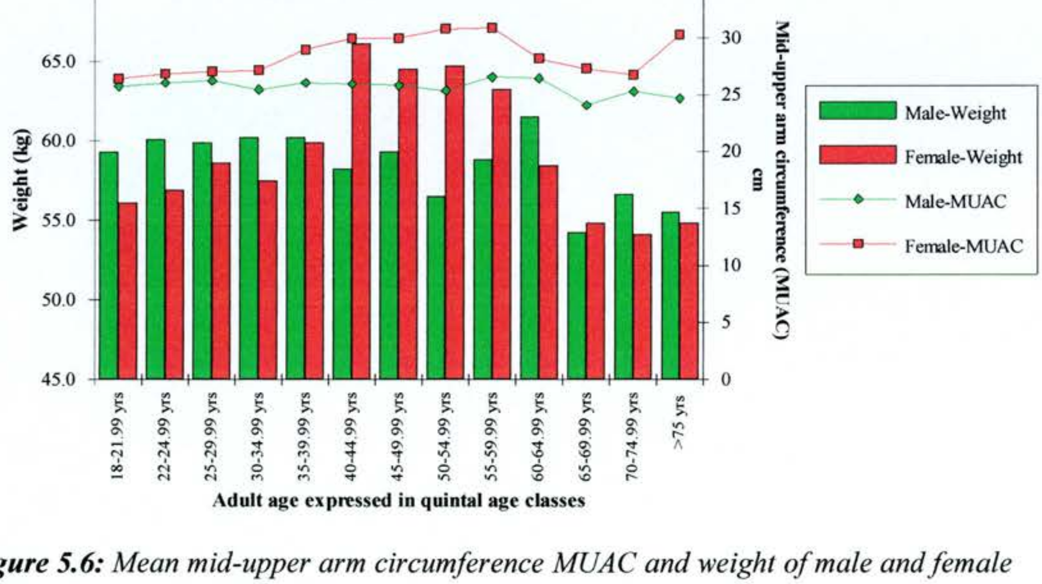

Figure 5.6: *Mean mid-upper arm circumference MUAC and weight of male and female adult ≥18 years population by quintal age classes measured in Mar-95.*

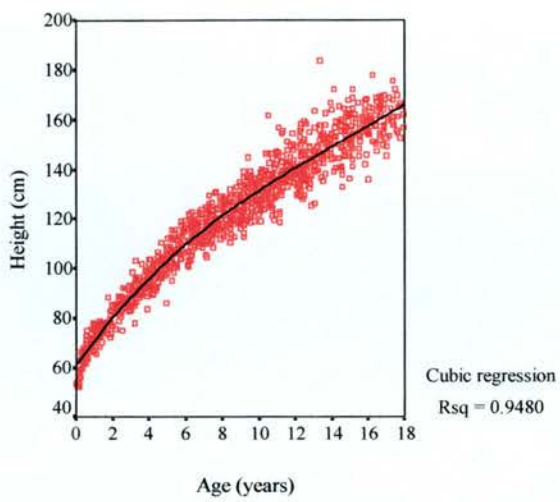

Figure 5.7: *Cubic regression (best fitting line) for child height (Whole child population 0-17.99 yrs.)*

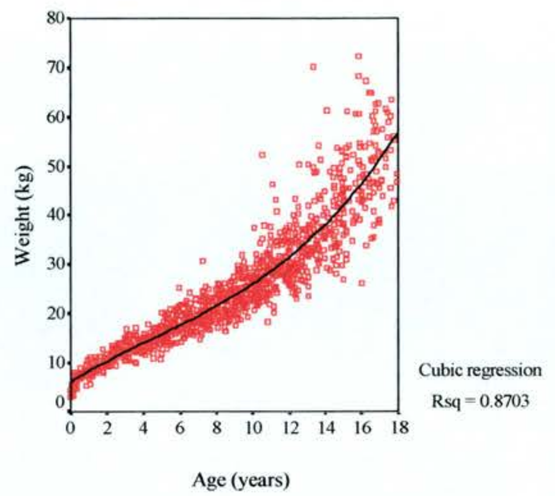

Figure 5.8: *Cubic regression (best fitting line) for child weight (Whole child population 0-17.99 yrs.)*

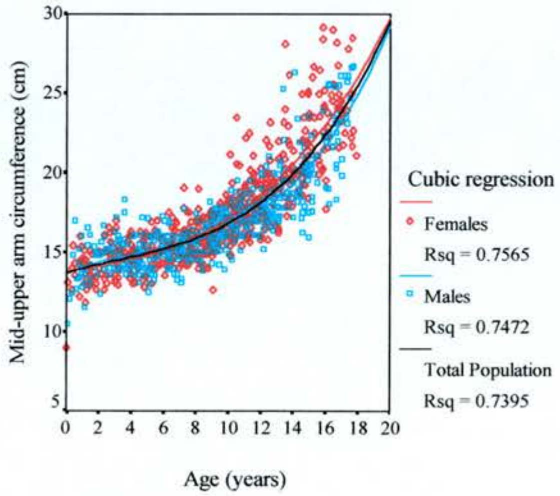

Figure 5.9: *Cubic regression (best fitting line) for child mid-upper arm circumference MUAC (Whole child population 0-17.99 yrs.)*

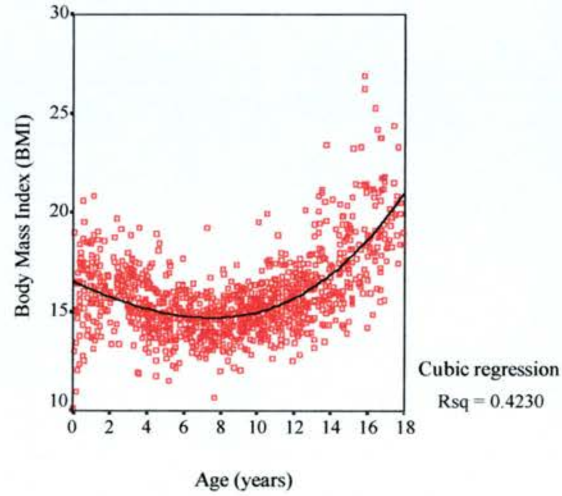

Figure 5.10: *Cubic regression (best fitting line) for child Body Mass Index (BMI) Whole child population 0-17.99 yrs.)*

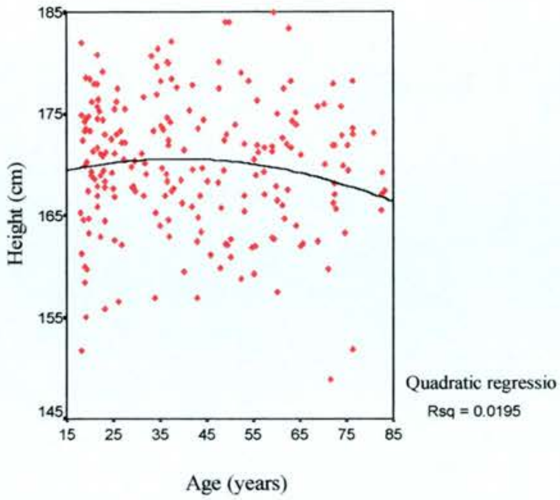

Figure 5.11: *Quadratic regression (Best Fit) of adult male height (>18 years)*

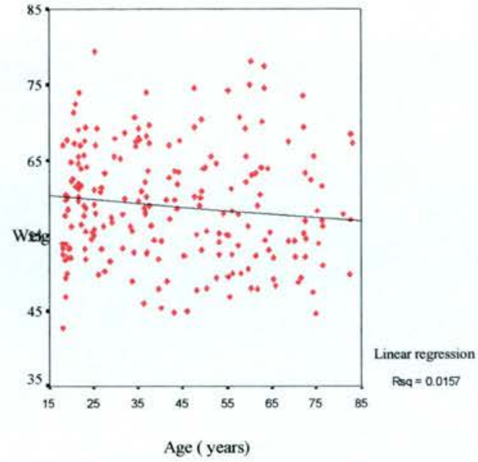

Figure 5.12: *Linear regression (Best Fit) of Adult Male Weight (>18 years)*

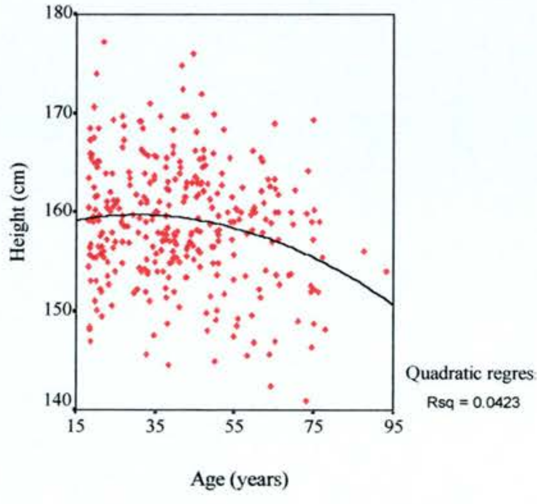

Figure 5.13: *Quadratic regression (Best Fit) of adult female height (>18 years)*

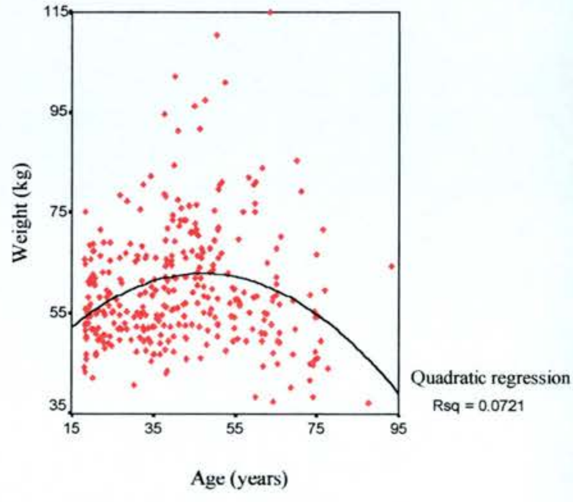

Figure 5.14 : *Quadratic regression (Best Fit) of adult female weight (>18 years)*

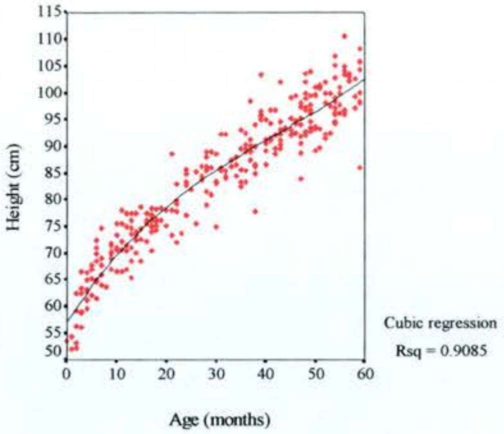

Figure 5.15: *Scatter plot and cubic regression (best fitting line) of the relation between height and age for pre-school children 0-4.99 years*

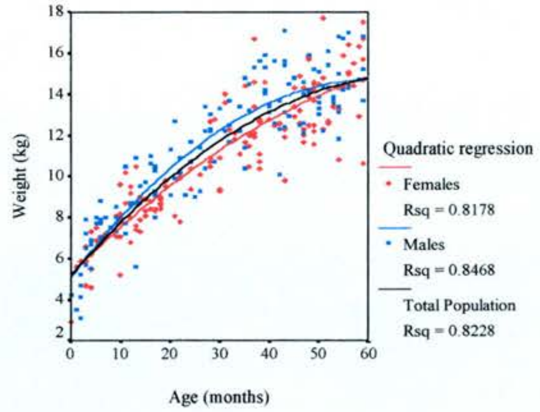

Figure 5.16*: Scatter plot and quadratic regression (best fitting line) of the relation between weight and age for pre-school children 0-4.99 years*

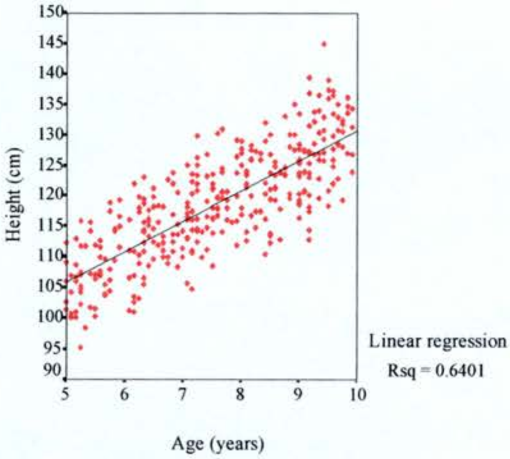

Figure 5.17: *Scatter plot and cubic regression (best fitting line) of the relation between height and age for primary school children 5-9.99 years*

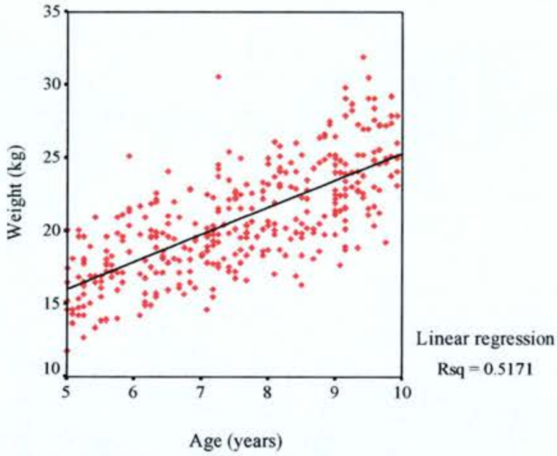

Figure 5.18:*: Scatter plot and linear regression (best fitting line) of the relation between weight and age for primary school children 5-9.99 years.*

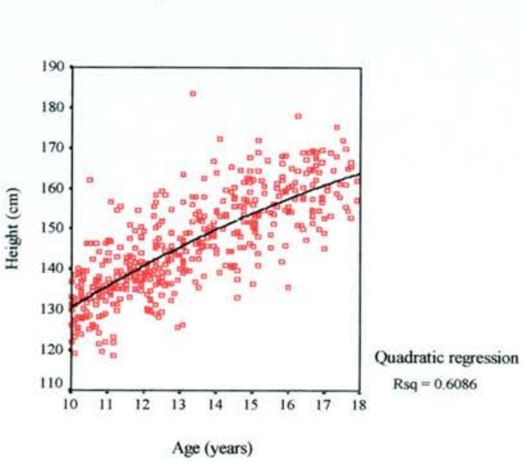

Figure 5.19:*: Scatter plot and quadratic regression (best fitting line) of the relation between height and age for adolescents 10-17.99 years*

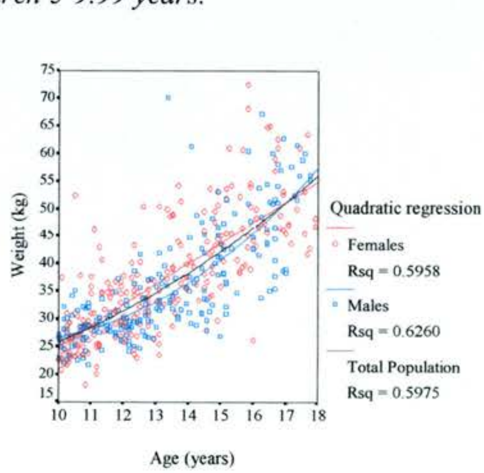

Figure 5.20: *Scatter plot and quadratic regression (best fitting line) of the relation between weight and age for adolescents 10-17.99 years*

Figures for section 5.4

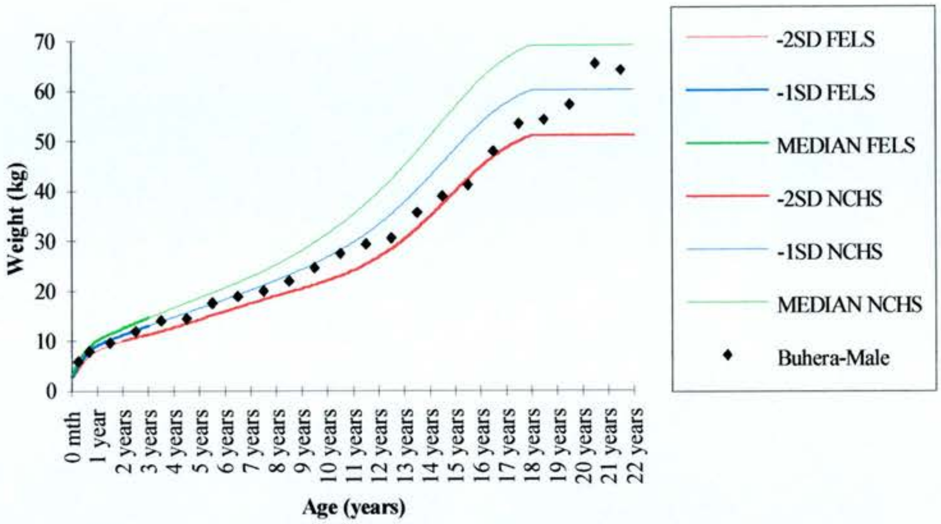

Figure 5.21: *Mean attained weight (kg) by yearly age classes for Buhera males (0-22 years) compared to NCHS median and Standard Deviations (SD).*

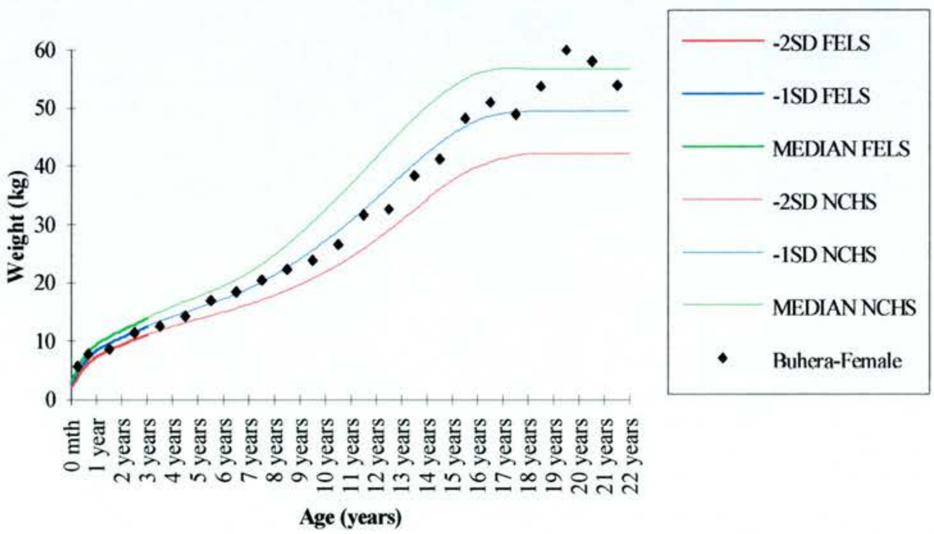

Figure 5.22: *Mean attained weight (kg) by yearly age classes for Buhera females (0-22 years) compared to NCHS median and Standard Deviations (SD).*

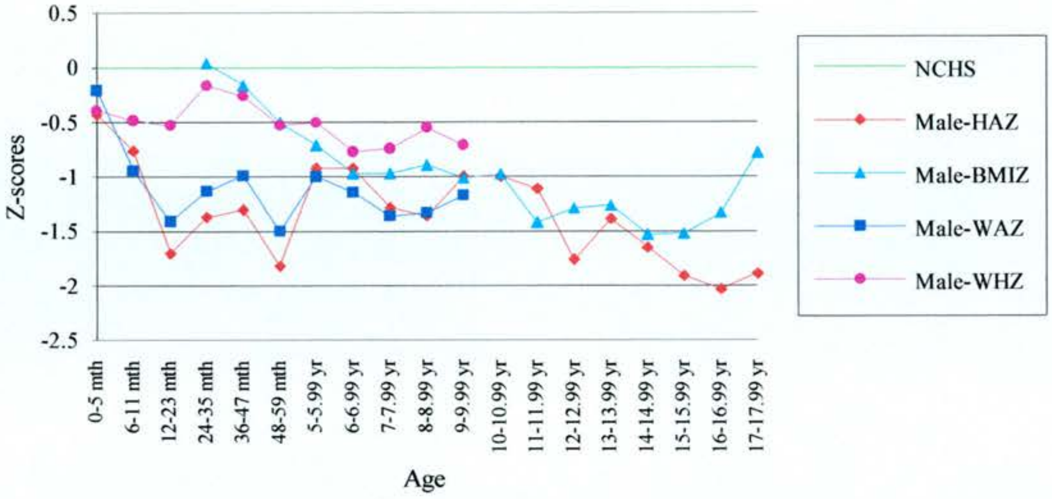

Figure 5.23: *Mean Z-scores Height for age (HAZ), Body Mass Index for age (BMIZ), Weight for age (WAZ) and Weight for height (WHZ) by yearly age classes for male children (0-17.99 years)*

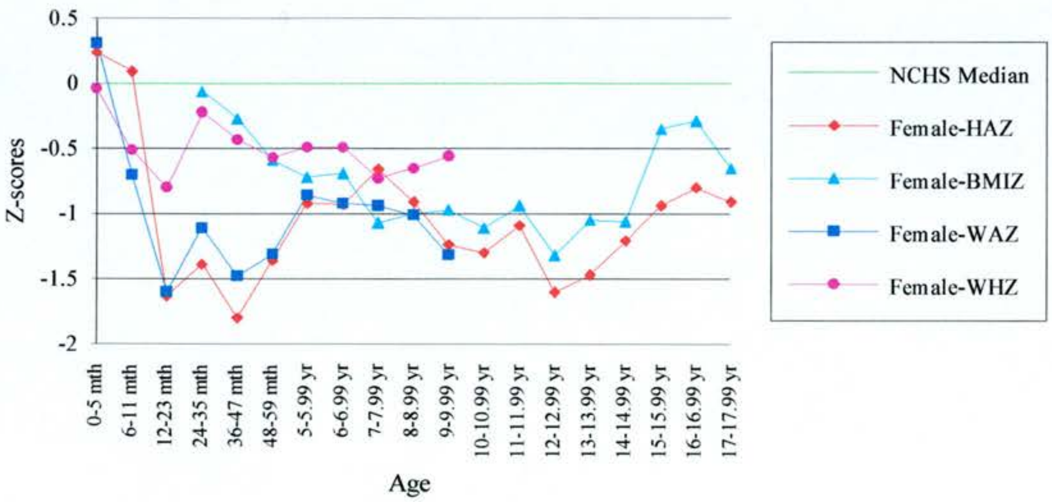

Figure 5.24: *Mean Z-scores Height for age (HAZ), Body Mass Index for age (BMIZ), Weight for age (WAZ) and Weight for height (WHZ) by yearly age classes for female children (0-17.99 years)*

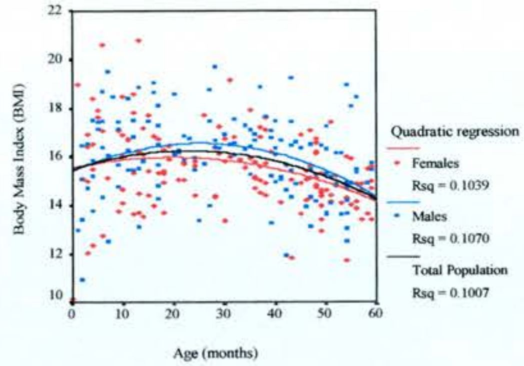

Figure 5.25: *Scatter plot and quadratic regression (best fitting line) of the relation between BMI and age for pre-school*

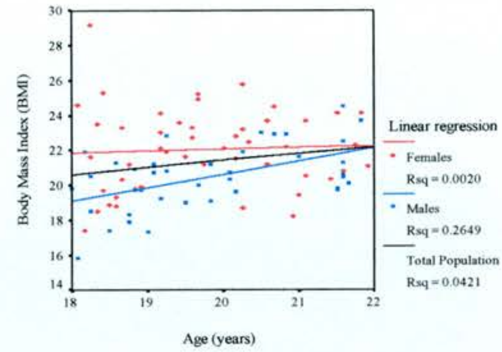

Figure 5.26: *Scatter plot and linear regression (best fitting line) of the relation between BMI and age for young adults (18-21.99 years)*

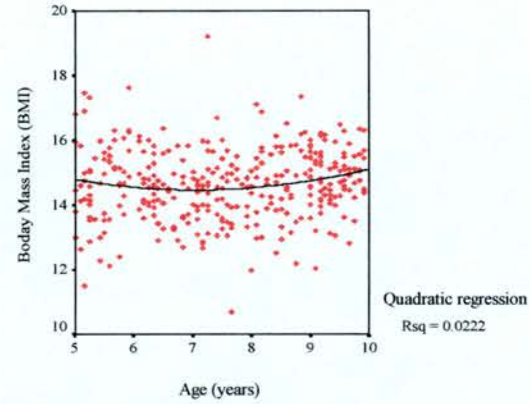

Figure 5.27: *Scatter plot and quadratic regression (best fitting line) of the relation between BMI and age for primary school*

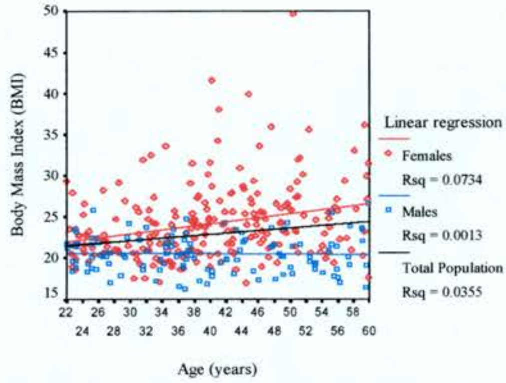

Figure 5.28: *Scatter plot and linear regression (best fitting line) of the relation between BMI and age for middle-aged adults*

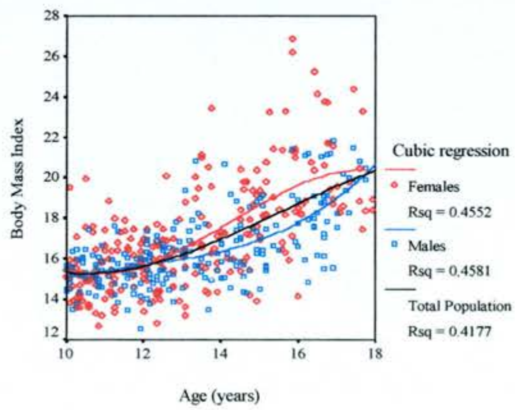

Figure 5.29: *Scatter plot and cubic regression (best fitting line) of the relation between BMI and age for adolescents*

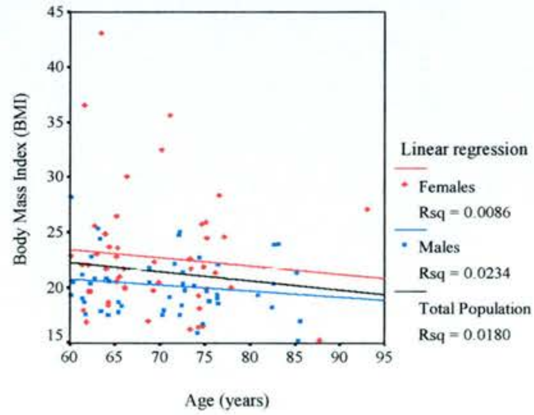

Figure 5.30: *Scatter plot and linear regression (best fitting line) of the relation between BMI and age for elderly*

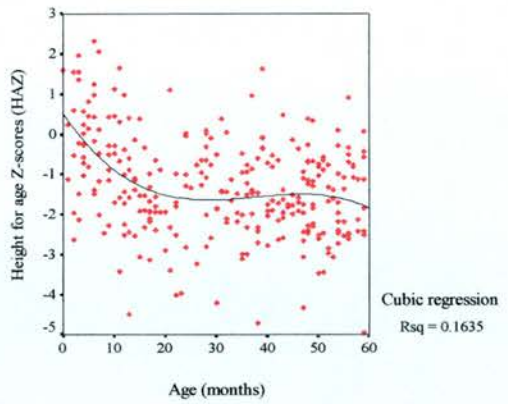

Figure 5.31: *Scatter plot and cubic regression (best fitting line) of the relation between HAZ and age for pre-school children*

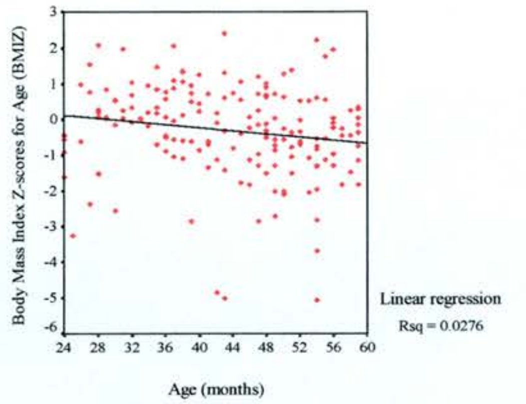

Figure 5.34: *Scatter plot and linear regression (best fitting line) of the relation between BMIZ and age for pre-school children*

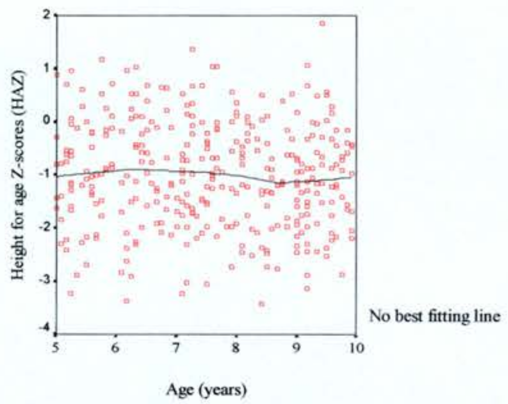

Figure 5.32: *Scatter plot of the relation between HAZ and age for primary school children (No best fitting line)*

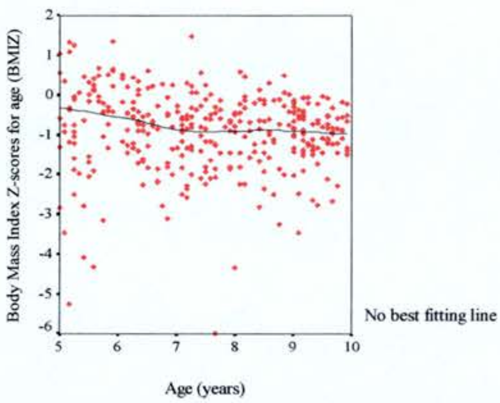

Figure 5.35: *Scatter plot of the relation between BMIZ and age for primary school children (No best fitting line)*

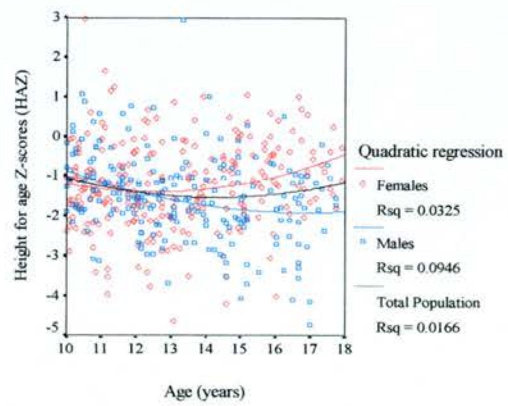

Figure 5.33: *Scatter plot and quadratic regression (best fitting line) of the relation between HAZ and age for adolescents*

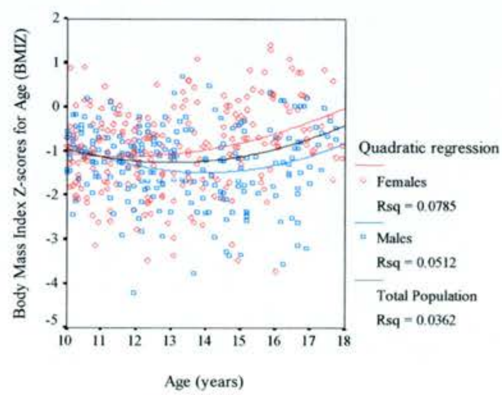

Figure 5.36: *Scatter plot and quadratic regression (best fitting line) of the relation between BMIZ and age for adolescents*

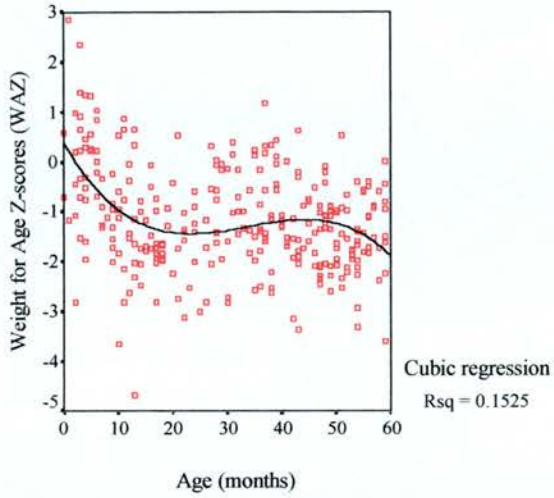

Figure 5.37: *Scatter plot and cubic regression (best fitting line) of the relation between WAZ and age for pre-school children*

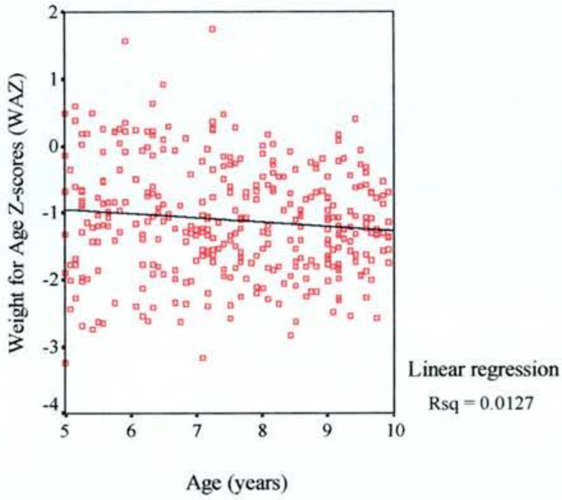

Figure 5.38: *Scatter plot and linear regression (best fitting line) of the relation between WAZ and age for primary school children*

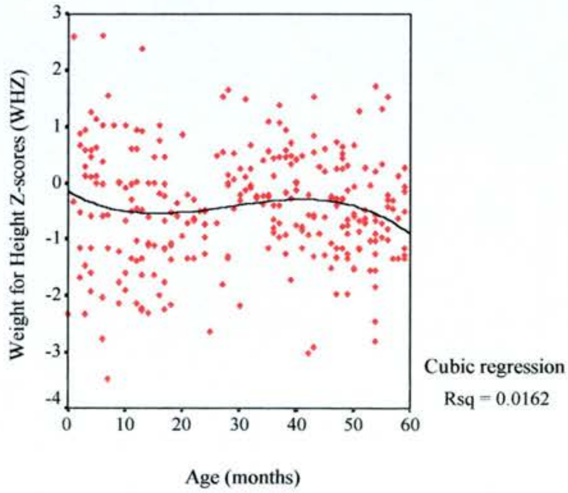

Figure 5.39: *Scatter plot and cubic regression (best fitting line, not significant) of the relation between WHZ and age for pre-school children*

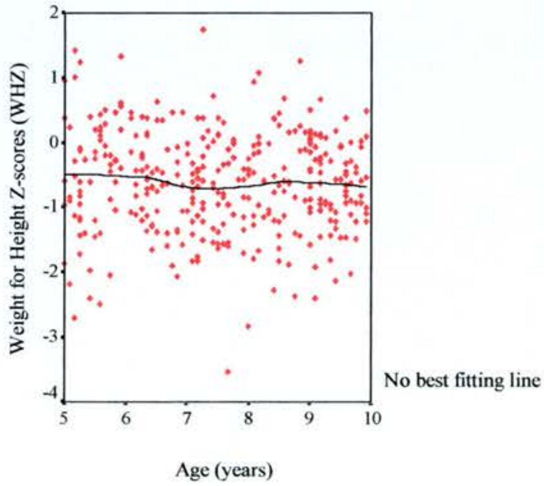

Figure 5.40: *Scatter plot (no best fitting line) of the relation between WHZ and age for primary school children*

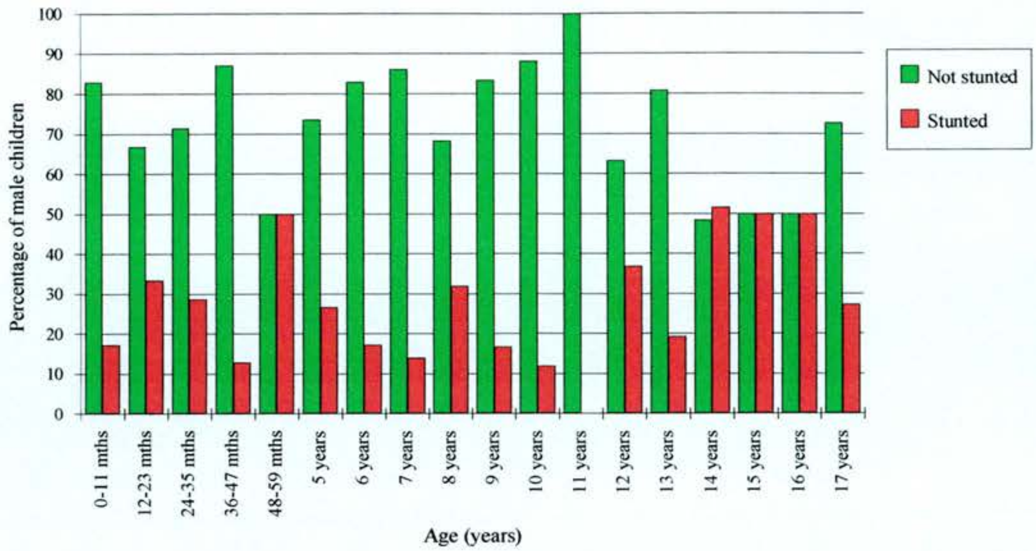

Figure 5.41: Association between yearly age classes and the prevalence of stunting *(<-2 HAZ) amongst the male child population*

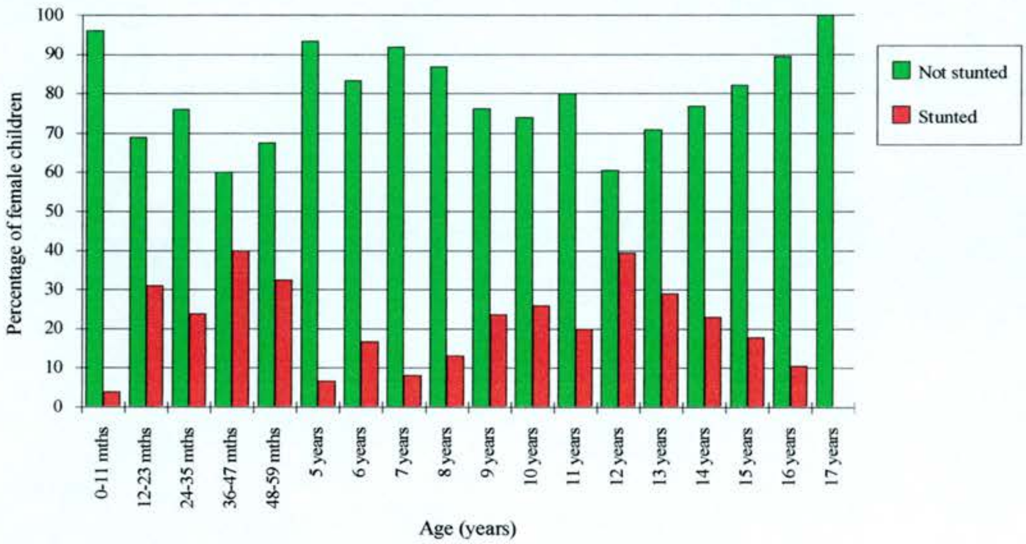

Figure 5.42: Association between yearly age classes and the prevalence of stunting *(<-2 HAZ) amongst the female child population*

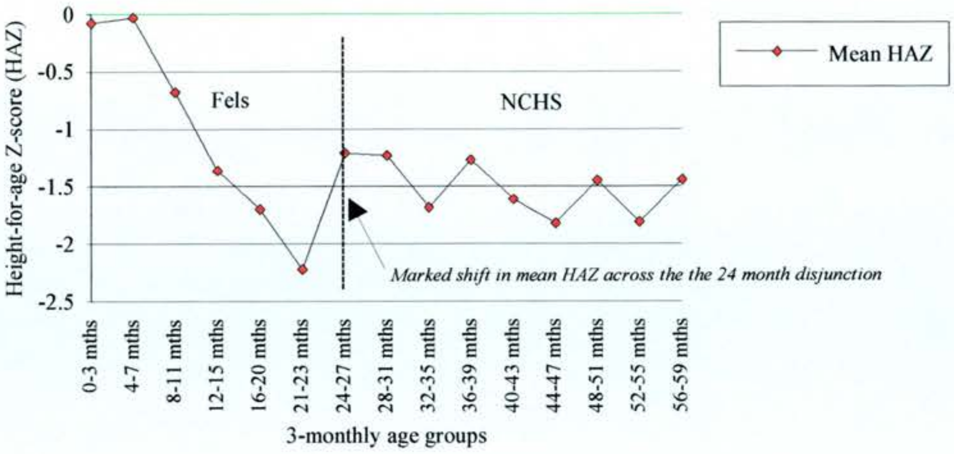

Figure 5.43: *Mean HAZ for pre-school population by 3-monthly age classes illustrating the marked shift in the mean Z-score across the 24 month disjunction*

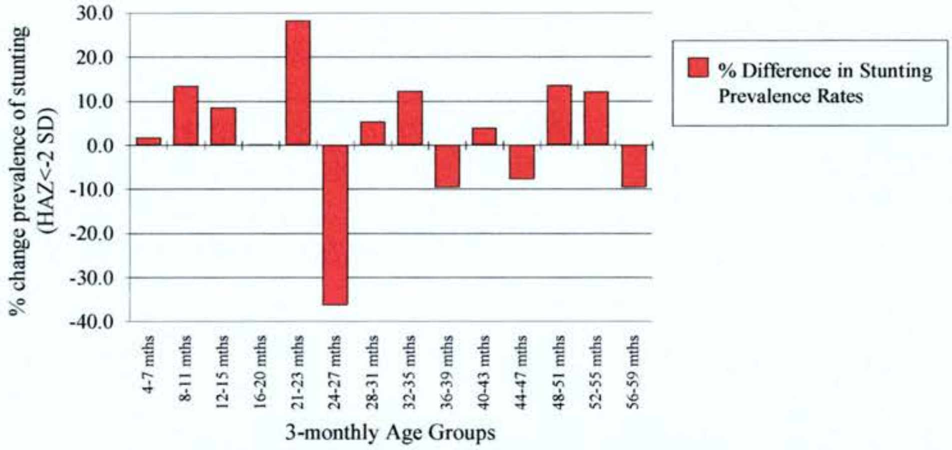

Figure 5.44: *Change in prevalence of stunting (<-2 HAZ) by successive 3-monthly age classes for the pre-school population*

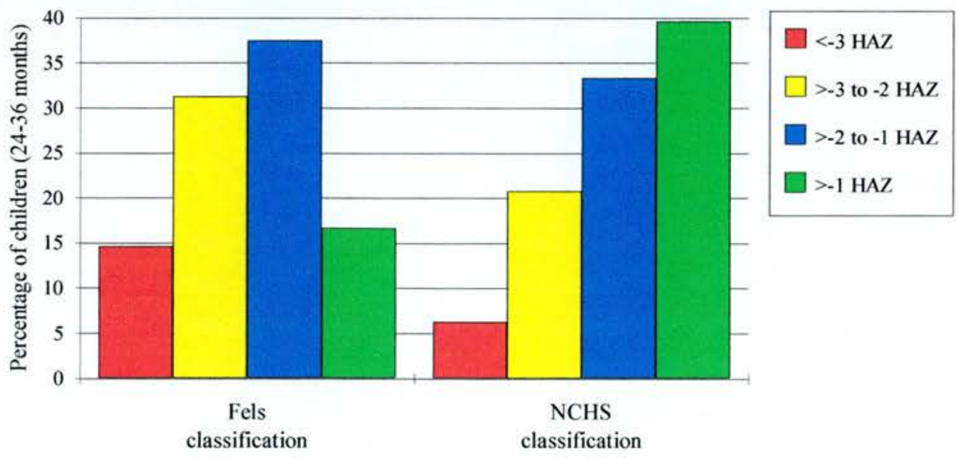

Figure 5.45: Proportion (%) of children (24-36 months) categorised as severely, moderately, or mildly stunted or of adequate HA using the Fels and NCHS growth reference data

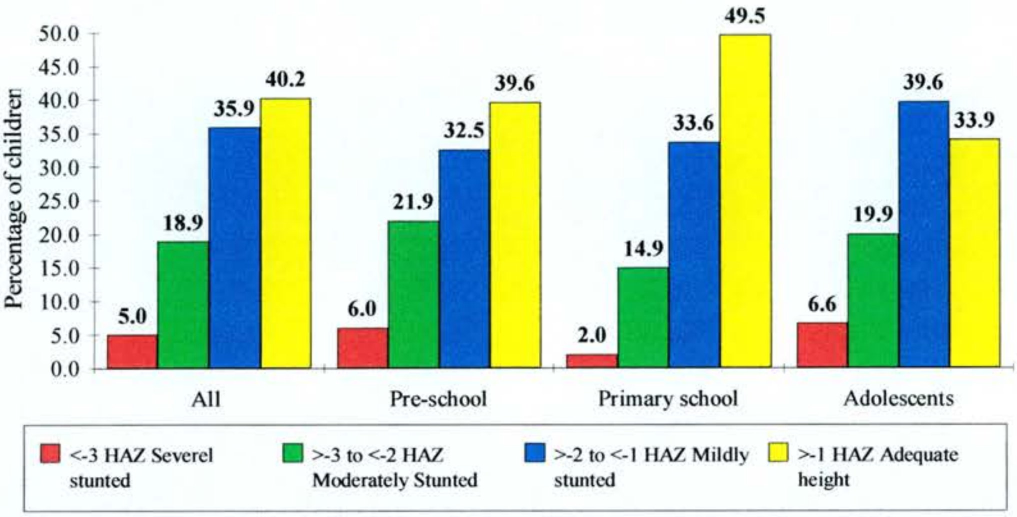

Figure 5.46: *Association between the three discrete periods of childhood and the degree of stunting χ^2=28.627, df=6, p<0.001*

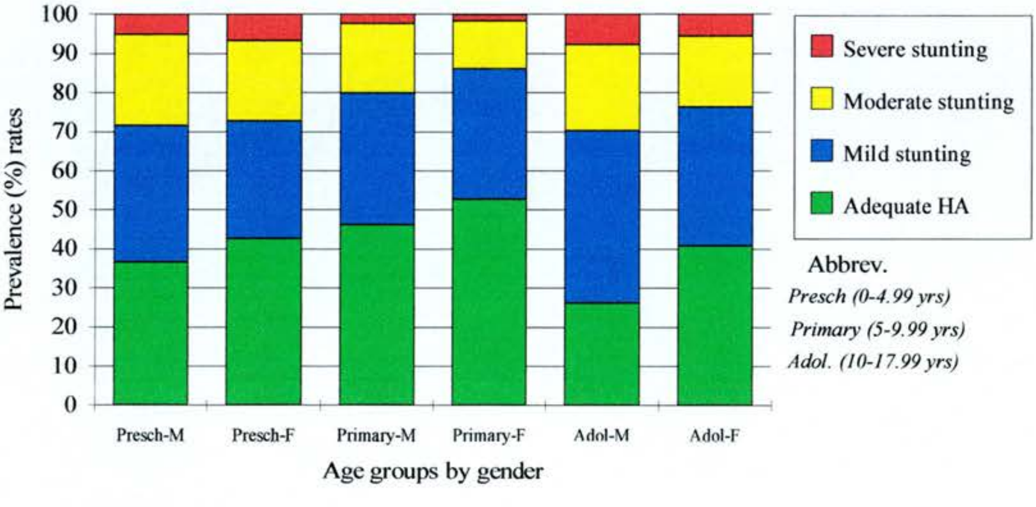

Figure 5.47: *Association between degrees of stunting and gender by the three discrete periods of childhood.*
Pre-school children: *χ^2=1.769; df=3; n.s.*
Primary school children: *χ^2=2.693; df=3; n.s.*
Adolescents: *χ^2=11.272; df=3; p=0.010*

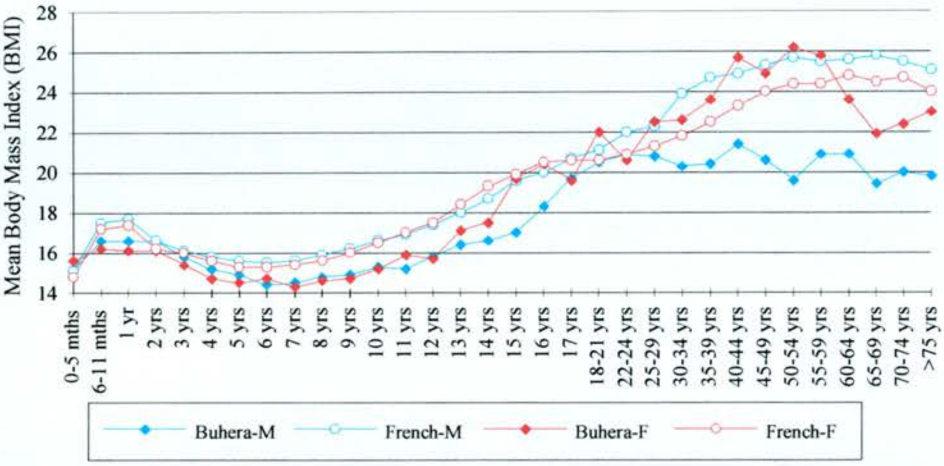

Figure 5.48: *Comparing the distribution of male and female mean BMI throughout the life-span for the Buhera and French Population * Source: Rolland-Cachera et al, 1991*

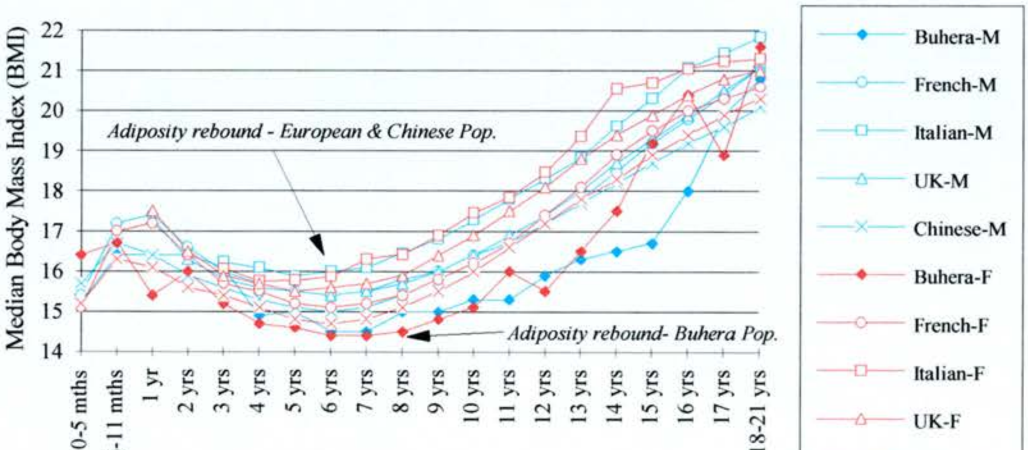

Figure 5.49: *Distribution of child median BMI illustrating the timing of the adiposity rebound within different populations*

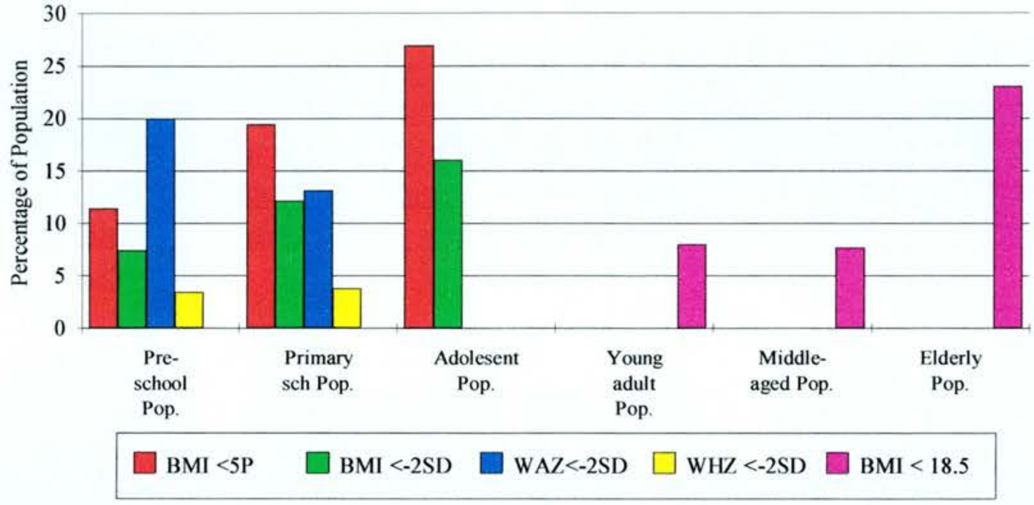

Figure 5.50: *Prevalence of malnourishment by age group using different weight for height indicators and cut-off points*

CHAPTER 6 SEASONAL DYNAMICS OF MALNUTRITION IN BUHERA DISTRICT, ZIMBABWE

6.1 Introduction

This chapter examines the seasonal dynamics of nutritional status within and between household members residing in subsistent agricultural households in the Save communal area, Buhera district, Zimbabwe. In agricultural subsistent economies seasonality may influence nutritional status through a series of inter-linkages within the food and health system. In areas where food production is exclusively rain-fed the repeated inter-annual agricultural cycle is largely climatically governed. Zimbabwe experiences a unimodal climate, the subsistent farmers involved in the study were solely reliant on rain fed agriculture and dependent on one annual harvest. The Index of Agro-Climatic Seasonality (IACS) which uses rainfall data and soil characteristics to ascertain the degree of seasonal risk to food shortages suggested that the sampled households in Buhera were located in an area classified at moderate to severe risk of seasonality[1].

The prevailing climatic and soil conditions within Buhera district determined the cropping pattern which subsequently defined the seasonal pattern of food availability and demand for labour. The principal crop grown throughout the district was maize; this was supplemented by drought tolerant crops such as sorghum and millets. The agricultural cycle for maize and the drought tolerant crops were similar. Field preparation starts in late August, early September, with planting which was principally determined by the onset of the rains occuring around late October early to mid-November. Weeding takes place around two months later in January and harvesting in late March to end of April, depending on the seed variety and date the crop was planted. Hence, the agricultural year in Zimbabwe can be divided into three key

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[1] *Chapter three methodology section 3.3.2 describes in detail the IACS and its application to Buhera District.*

periods: the *pre-harvest* rainy period (Nov-Mar), *harvest* or *winter* period (Mar-Jul) and *post-harvest* period (Jul-Nov)[2].

The prevailing intra-annual pattern of seasonality causing transient food insecurity was further exacerbated during the 1994/5 agricultural cycle by the second worst drought in the region for a decade. The duration and magnitude of seasonal nutritional risk is principally determined by the pattern of rainfall; the insufficient and poor distribution of rains during the 1994/5 agricultural season caused the harvest to be declared a national disaster in March 1995. Subsequently, it was postulated that the chronically food insecure study population would exhibit pronounced physiological changes induced by acute food shortages brought about by the drought.

The distribution, extent and severity of the physiological impact of the seasonality phenomena within and between different members of rural subsistent agricultural households is still incompletely understood. A review of previous nutrition studies in Zimbabwe that had a seasonal component has produced inconsistent results and was predominantly focused on children. Many studies have documented weight change amongst adults or the seasonal effect on child growth but few have had the opportunity to explore these concurrently throughout the whole life-span. The Buhera study collected serial anthropometric measurements from all household members during the agricultural year thereby providing an unique opportunity to compare the physiological impact of seasonality within and between different age groups by gender.

The Buhera study observed the change in nutritional status throughout 1994/95 agricultural cycle from the start (Nov-94) through to the beginning of the next season (Nov-95). To assess the distribution, extent and severity of seasonality, repeated height, weight and MUAC measurements were taken at three key times during the year, namely, *pre-harvest or hungry period* (Nov-94 to Mar-95), *harvest period* (Mar-95 to Jul-95) and *post-harvest period* (Jul-95 to Nov-95). The difference in

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[2] *Chapter three methodology section 3.3.3 documents pertinent food and health characteristics*

adult weight, MUAC and BMI and child anthropometric indices were used to assess the physiological impact of seasonality on adult nutritional status and child growth performance within the Buhera population during the 1994/5 agricultural cycle. Disaggregation by gender and age groups were used to identify the demographic profile of household members deemed most at-risk of nutritional seasonality.

6.2 Derivation of the longitudinal samples and sample characteristics

6.2.1 Derivation of the longitudinal samples: Anthropometric measurements were taken from all household members for a maximum of 3 or 4 occasions during the Buhera study. The maximum number of observation periods an individual was measured was determined by the household's location. The first anthropometric survey round (Nov-94) was a trial round conducted in only three of the ten selected wards. Members of households located in either of three wards had an opportunity to be measured a maximum of four times, whereas the members of households in the remaining seven wards not selected in the initial trial round had a maximum of three repeat measures. Hence, two different longitudinal data sets were available for statistical analyses, the number of repeat measures determining sample allocation.

Longitudinal sample 1 with four repeat measurements had four possible calculations. Three 4-monthly pairwise comparisons to measure the change in nutritional status across each season: (*pre-harvest*: Nov.94-Mar.95), (*harvest*: Mar.95-Jul.95), (*post-harvest*: Jul.95-Nov.95) and one 12-month (*inter-annual*: Nov.94-Nov.95) to measure the inter-annual change in nutritional status. *Longitudinal sample 2* had three repeat measurements and three possible calculations: two 4-monthly pairwise comparisons: (*harvest*: Mar.95-Jul.95) and (*post-harvest*: Jul.95-Nov.95) and one 8-monthly pairwise comparison (*pre-harvest* versus *post-harvest*: Mar.95-Nov.95).

6.2.2 Sample characteristics: the following sections describe gender and age distribution of the longitudinal samples and evaluates their representativeness.

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associated with each season.

6.2.3 Exclusion criterion for repeat measures - adults: A total of 93 adults aged >18 years measured during the trial survey in Nov-94 had four repeat measurements taken during the year. Approximately, a fifth (21.5%) of the adults were excluded from the analysis, 18 (19.4%) were reported to be pregnant or lactating and 2 had excessive (±18%) weight change in one of the 4-monthly observation periods. After applying the exclusion criteria longitudinal sample 1 with 4 repeat measures consisted of 73 adults. Longitudinal sample 2 with three repeat measurements was approximately three times larger than longitudinal sample 1. A total of 278 adults attended all three anthropometric surveys conducted in 1995. Thirty-six or 12.9% of the sample were excluded: 33 (11.9%) were pregnant or lactating during 1995, one was double entered and 2 had large weight fluctuations (±16%). After applying the exclusion criteria longitudinal sample 2 consisted of 245 adults.

6.2.4 Exclusion criterion for repeat measures - children and adolescents: A total of 202 children aged <18 years in Nov-94 had four repeat measures taken during the year. Of these, 14 or 7.0% of the total sample were subsequently excluded: 1 (0.5%) was lactating, 5 (2.5%) were misidentified possessing gross weight and height measurement errors, and 8 (4.0%) had large unaccountable positive or negative weight oscillations. An additional 569 children had three repeat measurements taken in Mar-95, Jul-95 and Nov-95; of these 23 or 4.0% of the sample were excluded after data transformations highlighted excessive unaccountable weight or height oscillations. After the exclusions the longitudinal child sample 1 with 4 repeat measures consisted of 188 children and longitudinal child sample 2 with 3 repeat measures consisted of 546 children. After comparing and establishing that there was minimal differences between the anthropometric measurements and indicators derived from child longitudinal sample 1 and 2 the two samples were combined and analysed as one sample for the three overlapping survey rounds namely Mar-95, Jul-95 and Nov-95 thereby increasing the child sample size by a third to 734 children.

6.2.5 Evaluation of the representativeness of the longitudinal samples - adults: A comparison of the demographic composition, anthropometric measures and indicators between the two longitudinal samples and the cross-sectional sample of household members who had been measured on at least one occasion but had participated less than three times due to various personal or professional reasons was carried out to test for significant differences between the three samples by survey round. The results of these comparisons by gender and age are summarised for adults in Appendix 4 - Tables 6.2.1-6.2.4.

Adult longitudinal sample 1 with four repeat anthropometric measures consisted of 73 adults, 23 (31.5%) men and 50 (68.5%) women. *Adult longitudinal sample 2* with three repeat anthropometric measures consisted of 318 adults, 110 (34.6%) men and 208 (65.4%) women. As observed in the cross-sectional analyses the proportion of adult men to women measured was approximately 1:3; this gender ratio remained in the longitudinal samples. Males assigned to longitudinal sample 1 (n=23) were significantly older than the cross-sectional samples in all survey rounds. Males in longitudinal sample 2 were also on average 10 years younger than males in longitudinal sample 1; the age difference between the two longitudinal samples was statistically insignificant. The highly significant age difference between sample 1 and the cross-sectional samples confirms the relatively transient nature of younger males who regularly migrate in and out of the district looking for work. Despite this significant age variance the differences in the mean anthropometric measures (weight, height, MUAC), mean absolute and relative change in weight or MUAC, or indicators (mean BMI or prevalence rates of CED) between the three samples in each survey round were statistically insignificant after controlling for age.

The age differences observed between the two longitudinal female samples and the respective cross-sectional female samples were slightly less pronounced than that observed amongst the male samples but still highly significant in Mar-95 ($p<0.001$) and Nov-95 ($p<0.001$). In each of these survey rounds the cross-sectional sample was significantly younger than the two longitudinal samples. There were minimal age differences between the two longitudinal samples. There was no significant difference between the respective anthropometric measures or indicators with the exception of the absolute weight change between Mar-95 to Nov-95 (p=0.026) and the relative weight change (p=0.016) for the same period. The significantly younger cross-sectional sample of females gained weight during this period whereas the two longitudinal samples lost weight (Appendix 4-Table 6.2.4).

These results suggest that despite the significantly reduced sample sizes and age differences amongst men, the anthropometric status of the longitudinal adult populations were not significantly different from the cross-sectional samples and were deemed to be representative of the whole study population. The lack of any significant differences in the mean anthropometric measures and indicators between longitudinal sample 1 and 2 meant that data-sets could be combined when analysing the two 4-monthly pairwise observation periods *harvest* (Mar-95-Jul-95) and *post-harvest* (Jul-95 to Nov-95) in which the data overlapped, thereby increasing the sample size by a third to 318.

The combined longitudinal adult sample with three repeat measures (n=318) comprised of 31 (9.7%) young adults (18-21.99 years), 212 (66.7%) middle-aged (22-59.99 years) and 75 (23.6%) elderly (≥60 years). The sex ratio for the younger adults and the elderly age group was fairly evenly distributed, 0.8 and 1.02 females to 1 male respectively. In contrast, a significant gender disparity was evident within the middle-aged group, 2.8 females were measured to one male. The mean age of males were (48.3 ± 20.1 years), on average they were 4 years older than females (44.8 ± 15.3 years) the gender age difference was statistically insignificant.

6.3 Seasonal changes in adult weight, BMI and MUAC by gender and age

The relatively small size of adult sample 1 (n=73) allowed gender analysis only; it did not permit disaggregation by age group. The extent and severity of seasonal changes in nutritional status exhibited by young adults, the middle-aged and elderly were primarily examined using the larger longitudinal sample 2 (n=318). Trends in seasonal variation in both direct measures (weight and MUAC) and derived anthropometric index (BMI) were examined by analysis of covariance model for repeated measures.

The results of the repeated measure ANCOVA are summarised in Tables 6.3.1-6.3.19. The pattern of within and between subject seasonal variation differed by gender, age group, initial nutritional status and anthropometric measure.

6.3.1 Within and between-subject effect of gender on the seasonal variance of adult weight: Two repeated ANCOVA's were conducted to examine the seasonal variance in adult weight by gender. The first examined the between subject effect of gender alone. The second examined the between subject effect of gender but took into account the significant difference in age between the male (54.3 ± 15.5 years) and female (44.6 ± 15.9 years) adults in longitudinal sample 1 (t=2.437, p=0.017) and included age as a covariate. The results of the repeated measures ANOVA and ANCOVA models were compared; both models gave similar within subject results but the inclusion of age as a covariate changed the result of the within subject contrasts suggesting that seasonal pattern of weight change was dependent on age rather than gender of adults. This is elaborated further below.

The results of both models, the repeat measures ANOVA and ANCOVA indicated that there was a highly significant within subject variation in weight across the four survey rounds (p=0.001) and insignificant seasonal variation in weight by gender. The ANCOVA model which included age as a covariate suggested that there was a moderate significant within subject effect between weight and age (p=0.022) and slight interaction between weight, gender and age (p=0.048) (Table 6.3.1).

Within subject contrasts were used to examine the seasonal variation in the mean weight from survey round to survey round. The measurements taken in Nov-94, Mar-95, Jul-95 and Nov-95 were compared in a sequential manner using three pairwise comparisons thus representing the three different seasons: *pre-harvest* (Nov-94 versus Mar-95) *harvest* (Mar-95 versus Jul-95) and *post-harvest* (Jul-95 to Nov-95), respectively. The repeat measure ANOVA analysis omitting age as a covariate suggested that there was significant within subject heterogeneity due to the difference in mean weight observed during the *pre-harvest* and *post-harvest* periods. A significant weight gain (2.226 kg) was observed in *pre-harvest* period (F=88.494; $p<0.001$) and significant weight loss (-1.573 kg) was observed in *post-harvest* period (F=39.470; $p<0.001$). The slight decline in weight (-0.335 kg) observed during the *harvest* period was statistically insignificant. Hence, the two pairwise comparisons reflecting the largest changes in mean weight were statistically significant whereas the relatively smaller negative change in weight observed during the *harvest* period was statistically insignificant (Table 6.3.4).

After controlling for age the notable within subject weight gain (2.373 kg) observed during the *pre-harvest* period, remained highly significant (F=14.818; $p<0.001$). The inconsequential negative weight change (-0.381kg) which occurred during the *harvest* period, also emerged as statistically significant with the inclusion of age as a covariate (F=5.035; $p=0.028$). However the relatively larger within subject *post-harvest* weight loss (-1.366 kg) became statistically insignificant with the inclusion of age as a covariate. These results suggest that age was an important between subject factor influencing both the direction and extent of the seasonal weight changes[3].

Using either the ANOVA or ANCOVA model the within subject weightxgender interaction was statistically insignificant across survey rounds, suggesting that the seasonal pattern in weight change and the amount of weight lost and gained during each survey round were similar for men and women. On average women gained slightly more weight during the *pre-harvest* period and lost slightly less weight during the *harvest* period. During the *post-harvest* period weight declined for both sexes, on average women lost slightly more than men. In each season the weight differences by gender were statistically insignificant (Table 6.3.4).

In contrast, the repeat measures ANOVA and ANCOVA that examined *inter-annual* weight change revealed different results (Tables 6.3.9-6.3.10). The within subject *inter-annual* weight change using the ANOVA model which omitted age as a

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[3] ***Note:*** *The slight differences in adjusted mean weights between survey rounds and the F values for the ANOVA and ANCOVA models can be explained by the two extra interactions in the ANCOVA model that included age as a covariate (weightxage) and (weightxsexxage) that were obviously omitted in the ANOVA model.*

covariate suggested that over the year on average men lost a minimal amount of body weight (-0.087 kg) and women gained weight (0.724 kg). The overall within subject mean weight change for adults during the year was statistically insignificant as was the between subject weightxgender interaction. However, after controlling for age the year on year weight change was positive for both genders. On average the gain in weight for men was minimal (0.473 kg) and statistically insignificant. In contrast, the inter-annual gain in weight (0.779 kg) for women was statistically significant (paired *t*-test: t=2.124; p=0.039). The association between weight gain and the within-subject effect of gender was also statistically significant (p=0.030), suggesting that the 0.306 kg gender difference in the inter-annual weight gain were significantly different.

This is probably partially explained by the inclusion of four multiple interactions within the ANCOVA model. The ANCOVA model concurrently examined the inter-annual change in weight *per se*, the inter-annual weightxage interaction, inter-annual weightxgender interaction and the inter-annual weightxgenderxage interactions simultaneously. The model suggested that due to the highly significant interaction between the inter-annual weightxgenderxage (F=7.121, p=0.009), the inter-annual weight difference *per se* was significantly different (F=4.524; p=0.037) and the inter-annual weightxgender interaction was also statistically significant (F=4.904; p=0.030). These results should however be interpreted with caution since a series of multiple comparisons can by chance lead to a significant difference. Applying the Bonferroni's correction, the observed significance level for each comparison must be less than 0.0125 for the difference to be significant. Hence, the inter-annual weight difference *per se* and inter-annual weightxgender interaction would no longer be considered significant. In addition, the relatively small sample size particularly for the men (n=23) could also lead to some distortion. Overall, these results suggest that during the poor 1994/5 agricultural harvest adults unexpectedly maintained their nutritional status, in fact women on average gained weight whereas the men's weight remained virtual static suggesting women faired best during the drought.

The between-subject effects of gender, age and genderxage interaction were statistically insignificant suggesting that there was no significant difference between the adjusted mean weight of men and women based on the average of the four weight measures either controlling for age or not.

6.3.2 Within and between-subject effect of age on the seasonal variance of adult weight: The age effect on seasonal weight change was examined more closely using multi-regression analyses. Delta weights computed for each of the three 4-monthly pairwise observations were regressed on age. The relationship between age and the three 4-monthly pairwise observations differed. In the *pre-harvest* and *harvest* periods a significant curvilinear relationship was observed with age, whereas during *post-harvest* period a significant inverse linear relationship was observed (Appendix 4-Table 6.3.20). The relationship between *pre-harvest*, *harvest* and *post-harvest* delta weight and age are depicted in Figures 6.10-6.13. It is evident from these results that in the *pre-harvest* period the middle-aged gained more weight than the elderly and young adult population, the younger adults gaining the least (Figure 6.10). During the *harvest* period the converse situation was observed, on average the youth gained the most weight, the elderly population on average also had a positive weight change whereas middle-aged adults exhibited weight loss (Figure 6.11). There was a significant inverse linear relationship with age and the *post-harvest* weight change ($p=0.002$) (Figure 6.12). On average all age groups lost weight during this period, the amount lost increasing -0.045 kg with each year of age (Appendix 4-Table 6.3.20). Inter-annually there was an overall insignificant inverse linear relationship between weight and age young adults gaining the most weight, the middle aged also had a positive change in weight whereas the elderly lost weight (Table 6.3.11). Figure 6.11 clearly illustrates the gender disparity between the inter-annual change in weight and age. Amongst women there was a slight positive incline with age suggesting that older women faired best in drought whereas amongst men there was a significant inverse relationship with age indicating that they progressively lost more weight with age suggesting that elderly men faired worst in the drought.

6.3.3 Within and between-subject effect of age groups on the seasonal variance of adult weight: The relatively larger sample size of the combined longitudinal samples 1 and 2 permitted disaggregation into the three discrete periods of adulthood by gender. In this analysis age group was entered as a categorical variable with gender as a between subject factor. Then the within and between subject effect of both age group and gender on the three serial weight measures obtained during 1995 were examined using repeated measures analysis. The tests of weight alone indicated significant within-subject differences between the three repeat weight measures ($p<0.001$) and a significant within-subject difference between weightxage group ($p<0.001$) was also observed, whereas the within-subject effect of weightxgender and weightxage groupxgender were both statistically insignificant (Table 6.3.13).

The significant within-subject heterogeneity was due to both the overall highly significant weight gain (0.532 kg) observed during *harvest* period ($p=0.001$) and highly significant weight loss (-1.345 kg) observed during the *post-harvest* period ($p<0.001$). In contrast the within-subject analysis of weightxage group were due to highly significant differences that emerged in *harvest* period only ($p<0.001$). Divergent patterns of weight change were observed by age group: on average young adults (1.507 kg) and the elderly (0.271 kg) both gained weight during *harvest* whereas the middle-aged (-0.183 kg) lost weight (Table 6.3.16). This pattern of weight change was observed for both males and females (Figure 6.6). In contrast, within-subject effect between weightxage group observed during the *post-harvest* period was statistically insignificant. Subjects within all three discrete periods of adulthood followed the same seasonal pattern and on average lost similar amounts of weight. Young adults lost the least (-1.091 kg), and the elderly lost the most (-1.619kg) during the *post-harvest* season (Table 6.3.16). It is evident from this analysis that the pattern of seasonal energy stresses differed by age during the *harvest* period but were similar during the *post-harvest* period.

The results of the repeated measures ANOVA examining the change in weight over the eight month period (Mar-95 to Nov-95) suggested that there was a significant within-subject loss in weight (-0.813 kg). In addition, there was a significant within-subject weightxage group interaction. On average both the middle aged and elderly lost weight whereas the younger adults gained weight. The middle-aged were the most vulnerable exposed to highest level of seasonal stress losing -1.507 kg, which was equivalent to 2.49% of their initial body weight in Mar-95. The elderly lost slightly less weight (-1.347 kg) whereas in relative terms the 2.376% equivalent loss of the initial body weight was similar to middle-aged adults. In contrast, the younger adults gained 0.416 kg in weight, equivalent to 0.8% increase in their initial body weight (statistics not tabulated).

6.3.4 The distribution, extent and severity of seasonal weight change: The remarkable similarity of mean adult inter-annual weight (Nov-94: 58.9±12.0 kg) versus (Nov-95: 59.4±11.6 kg) suggests that year on year fluctuations in the overall mean weight of the adult population was minimal, 0.5 ± 2.4 kg approximately equivalent to a relative body weight change of 1.0 ± 4.3 %. In contrast, within particular seasons there were statistically significant oscillations. The observed overall mean absolute *pre-harvest* weight gain 2.3 ± 1.9 kg were equivalent to 4.0 ± 3.4 % relative weight change. The significant *post-harvest* losses -2.4 ± 3.4 kg were equivalent to 1.5 ± 2.0 % body weight changes. Equally the large standard deviations and high coefficient of variance suggests that there was a large variability in both inter-annual and seasonal variation in weight within the adult population The absolute 4-monthly weight changes ranged between -6.4 kg to 6.5 kg; these changes were equivalent to a relative 4-monthly weight differences of between -11.2% to 13.6%.

To assess the extent and severity of within and between-subject seasonal weight change, the distribution of absolute and relative weight loss was examined. A review of previous seasonality studies considered a 5% weight loss as modest whereas clinical hospital based studies consider weight losses in excess of 7.5% over a three month period as severe. Applying these parameters as cut-off points the change in adult weight in each season was categorised into one of three groups based on the observed relative weight change over the 4-month period. A weight change ±0-4.99% was categorised as mild gain or loss, a weight change ±5-7.49% was classified as moderate gain or loss and a weight change ≥7.5% was considered a severe loss or large gain. It is recognised that the clinical significance of the amount of weight lost depends in part on previous nutritional status. This is examined later.

In the *pre-harvest* cycle, 90.4% of the adult population gained weight, 1.4% remained the same weight and 8.2% lost weight. Of those that gained weight, approximately, nearly two-thirds (60.6%) had a minor gain (0.1-4.9%), a fifth (22.7%) had a modest gain (5-7.5%) and further sixth (16.7%) exhibited large relative weight increases in excess of 7.5%. All of the subjects who lost weight during the *pre-harvest* period experienced a minor loss between (-0.1 to -4.9%) of their initial body weight (Table 6.3.25).

The measurements obtained for longitudinal sample 1 and 2 overlapped for two 4-monthly periods: *harvest period* and *post-harvest period*. The pattern and distribution of weight change exhibited by the two longitudinal samples varied slightly during the *harvest* period but were similar during the *post-harvest* period. During the *harvest* period, more than half (54.8%) of the longitudinal sample 1 lost weight. Of those that lost weight, the negative change in relative body weight was minor (-0.1 to -4.9%) for three quarters (75.0%) of the subjects, a further fifth (20.0%) exhibited a moderate negative change in their relative body weight and 5% experienced a severe weight loss ≥7.5% of their March body weight. Of those that gained weight during the *harvest* period the majority (84.8%) gained a minor amount, 0.1-4.9% of the previous body weight, 9.1% gained a moderate amount and 6.1% gained a large amount of weight. In comparison, just over half (51.8%) of adults in longitudinal sample 2 gained weight during the *harvest* period. As a result of the number of individuals losing weight in sample 1 and gaining weight in sample 2, the overall weight change observed during the *harvest* period was negative for sample 1 (-0.4 ± 1.9 kg) and positive for sample 2 (0.03 ± 2.2 kg). The variance in seasonal weight change between the two samples was attributed to the different age distributions, sample 2 was slightly younger than sample 1. Using the larger longitudinal sample 2 (n=318) to examine the distribution of weight change over the *harvest* period for the whole adult population a less pronounced or conclusive pattern emerged. Slightly more adults gained than lost weight (169 versus 149) and the weight remained static for 10 household residents. Whereas the association between age group and the distribution of *harvest* weight change was highly significant (p=0.012) (Table 6.3.26). The proportion of the middle-aged exhibiting severe, moderate and mild weight losses was significantly more than expected. Conversely, the proportion of young adults and elderly with mild weight gains and the number of young adults with moderate to large gains in weight were higher than expected.

In *post-harvest* period approximately three-quarters of adults measured in both longitudinal sample 1 and 2, lost weight. Within longitudinal sample 1 a slightly higher proportion of males (82.6%) lost weight during *the post-harvest* period compared to females (78.0%). In contrast within sample 2 the converse situation was observed with more females (77.9%) losing weight than males (72.7%). However, the association between gender and the distribution of *post-harvest* relative (%) weight change was statistically insignificant for both samples. Similarly, the association between age group and the distribution of *post-harvest* relative (%) weight change for longitudinal sample 2 was also statistically insignificant (Table 6.3.26).

6.3.5 Association between pre-harvest and post-harvest weight: Overall, the *pre-harvest* and *post-harvest* periods exhibited contrasting patterns of weight gain and loss, respectively. Bivariate correlations between *pre-harvest* and *post-harvest* seasonal absolute weight changes were statistically insignificant, suggesting that there was a limited association in seasonal weight changes during these two periods (Appendix 4-Table 6.3.23). Chi-square analysis was used to examine the association between the distribution of relative weight change during the *pre-harvest* and *post-harvest*. More than half (56.2%) of longitudinal sample 1 gained a mild amount of weight in the *pre-harvest* period (n=41); of these nearly two-thirds (61.0%) exhibited a relatively minor weight loss during the *post-harvest* period confirming the modest variation and relative stability of weight over the year. For both men and women the *pre-harvest* weight gains were significantly higher than the preceding *post-harvest* weight losses (paired t-test, <0.001) thereby contributing to the overall positive inter-annual weight gain.

6.3.6 Within and between-subject effect of gender and age on the seasonal variance of adult BMI: The seasonal change in BMI mirrored the seasonal pattern of weight change. The within-subject contrasts suggest that mean BMI increased significantly during the *pre-harvest* period from 21.9 in Nov-94 to peak at 22.8 in Mar-95 (p=0.001). Thereafter mean BMI subsequently declined, the overall deterioration in nutritional status during the *harvest* season was slight and statistically insignificant decreasing -0.13 to 22.7 in Jul-95. The significant within-subject weight loss that occurred during the *post-harvest* period had a notably negative impact on mean BMI which subsequently declined to 22.2 in Nov-95 (Figure 6.1). The within-subject contrasts of BMI for *post-harvest* period was also statistically insignificant whereas the interaction between BMI and age for this period was highly significant (p=0.001) verifying that the degree of impact of weight loss was a function of age. The overall within-subject gender differences were statistically insignificant suggesting that the seasonal change in male and female BMI followed a similar pattern. In contrast, the between-subject effect of gender was highly significant (p=0.001) corroborating the overall ponderous nature of women observed in the cross-sectional analysis (Table 6.3.2).

6.3.7 Within and between-subject effect of gender and age on the seasonal variance of adult mid-upper arm circumference (MUAC): The seasonal variation in MUAC followed a similar pattern as weight and BMI (Figure 6.1). However, the significance of the within-subject seasonal variation was slightly different. Unlike weight and BMI, the positive increase in mean MUAC observed in the *pre-harvest* period was statistically insignificant. Mirroring weight and BMI a statistically insignificant negative change in MUAC was observed in the *harvest* period. However, the relatively larger decrease in mean MUAC observed during the *post-harvest* period was highly significant (Figure 6.3). These results suggest that seasonal oscillations in mean MUAC are less pronounced compared to weight and BMI; only when the accompanying seasonal weight change is continual and relatively large is the change in mean MUAC notably expressed and statistically significant. The MUACxgender interaction was statistically insignificant for both longitudinal sample 1 and 2. In contrast, the within-subject age group effect was highly significant ($p<0.001$) (Table 6.3.10). The within-subject contrast highlighted that age determined the direction and degree of change in the MUAC measure in both the *harvest* and *post-harvest* seasons. During the *harvest* period the MUAC measure increased for both young male and female adults whereas there was a slight decrease in the elderly MUAC measure and virtually no change in middle-aged MUAC measure. The difference between the positive change in MUAC measure for young adults and the negative change for elderly was significant ($p=0.011$). Similarly, during the *post-harvest* period the MUAC measure of young adults continued to increase whereas the middle-aged and elderly MUAC decreased approximately 0.5 cm; the difference between the two older age groups and the younger adults was just significant ($p=0.034$). Figure 6.8 and 6.9 illustrate the different seasonal patterns of absolute and relative change in the MUAC measure by age group and gender.

6.3.8 Relationship between seasonal changes in MUAC, weight, BMI: The Buhera year long longitudinal study provided an invaluable opportunity to evaluate the potential use of MUAC as diagnostic tool to monitor seasonal change in nutritional status throughout the whole life-span. Serial MUAC measurements were compared to the repeated weight measures that had been taken concurrently to examine the relationship and the sensitivity of MUAC to detect change in adult and child nutritional status.

Bivariate correlation analyses suggest that there is a strong highly significant positive linear association between the seasonal changes in adult weight, BMI and MUAC. The strength and direction of the relationship between delta weight and MUAC and between delta BMI and MUAC were similar across seasons for both genders in each discrete period of adulthood. In the *pre-harvest*, *harvest* and *post-harvest* periods the correlation between weight and MUAC were $r=0.572$, $r=0.549$ and $r=0.458$, respectively; all were highly significant ($p<0.01$). Similarly the correlations between BMI and MUAC were r=0.583, r=0.526 and r=0.492, respectively; all were highly significant ($p<0.01$). Regressing *pre-harvest* seasonal delta MUAC on the *pre-harvest* delta weight suggested for each kilogram difference in weight there was an equivalent 0.644 cm difference in MUAC. A similar change in MUAC for 1 kg change in weight was observed in *harvest* period and *post-harvest* period, 0.758 cm and 1.016 cm, respectively. Throughout the year the seasonal variance in delta weight explained by the variation in MUAC decreased from 32% in the *pre-harvest* period to 29.0% in the *harvest* period and 19.8% in the *post-harvest* period (Appendix 4-Table 6.3.20).

To assess whether body fat or lean body mass was lost during the agricultural cycle cannot be resolved in this study since skin-folds or bio-electrical impedance measures used to compartmentalise body composition were not collected. In the absence of any biochemical markers to measure the physiological significance of the oscillation in body weight the distribution and degree of MUAC change was examined by initial nutritional status and relative amounts of weight lost or gained. A large negative change in MUAC was assumed to be indicative of substantial wasting of muscle and depletion of subcutaneous fat thereby reflecting more accurately the increase or decrease of tissue 'reserves' of energy and protein than body weight *per se*.

The association between initial nutritional status and subsequent prospective seasonal MUAC changes was statistically insignificant. In contrast, a series of one-way ANCOVA examining the association between seasonal absolute and relative MUAC changes and mild, moderate and severe relative weight gains and losses provided a clear distinctive linear trend after controlling for age. Of the 66 adults with four repeated weight and MUAC measures more than half (56.1%) concurrently exhibited mild weight gains (0.1-4.9%) in the *pre-harvest* period but a slight decrease in their absolute MUAC measure -0.2 cm which was equivalent to relative loss of -0.5%. Those experiencing a moderate or large gain in weight gained 0.9 cm (3.0%) and 1.4 cm (5.0%) in their MUAC measure, respectively. In contrast the small number of adults exhibiting a mild weight loss during the *pre-harvest* also experienced a corresponding decrease in their MUAC measure of -0.8 cm which was equivalent to a relative decline of -2.8%.

6.4 Seasonal changes in prevalence of Chronic energy deficiency (CED)

6.4.1 Seasonal variation in prevalence of Chronic Energy Deficiency (CED) by sample: The seasonal prevalence and distribution of BMI for the longitudinal sample 1 are summarised by gender in Tables 6.4.1-6.4.2. The seasonal prevalence and distribution of BMI for the longitudinal sample 2 are summarised by age groups and gender in Tables 6.4.3-6.4.10. The larger adult longitudinal sample 2 (n=245) with three repeat measures was combined with longitudinal sample 1 and used to substantiate the seasonal pattern of adult nutritional status established using the relatively smaller longitudinal sample 1. The lack of significant statistical differences observed between sample 1 and 2 verified at the outset when establishing the representativeness of the adult samples with repeat measures enabled the two longitudinal samples to be combined. The seasonal pattern and prevalence rates observed with sample 2 differed slightly from sample 1 and due to its size had an impact on the overall reported prevalence rates of CED for the combined sample. Sample 2 (n=245) exhibited a slightly higher prevalence of CED in Mar-95 (10.6%) and slightly lower prevalence rates in Jul-95 (9.8%) and Nov-95 (12.7%). The differences in prevalence rates between sample 1 and 2 were minimal 1%, 3.2% and 3.7% in Mar-95, Jul-95 and Nov-95, respectively. The lowest prevalence was observed in Mar-95 with sample 1 whereas the lowest incidence rate of CED for sample 2 was observed in Jul-95. Hence, during the *harvest* period the prevalence of CED increased slightly for sample 1 but declined slightly for sample 2. For both samples the highest prevalence rates of CED were observed in Nov-95. The above seasonal pattern of CED observed within sample 1 and 2 prevailed for both genders.

Throughout the year, no adult in longitudinal sample 1 was classified as severely CED; within sample 2 the prevalence of severe malnutrition was low, fluctuating between (0.9-1.6%). The seasonal prevalence rates of moderate and mild CED oscillated between (1.4-8.2%) and (6.8-15.1%), respectively within the smaller sample

1. In comparison, there was limited seasonal variation in prevalence rates of moderate (1.9-3.5%) and mild (7.2-8.5%) CED observed within the larger sample 2. At the other end of the spectrum, there was limited seasonal variation in prevalence rates of overweight, grade II and grade III obesity for both samples. Equally, the prevalence rates of over-nourishment within both samples were similar. The incidence of overweight ranged between (13.7-19.2%) for sample 1 and (13.2-16.7%) in sample 2. The seasonal incidence of grade II obesity varied between (5.5-6.8%) for sample 1 and (2.8-3.8%) for sample 2. The prevalence of grade III obesity was minimal and consistent throughout the year for both samples, measured as (0.9%) for sample 1 and (1.4%) for sample 2.

6.4.2 Seasonal variation in prevalence of Chronic Energy Deficiency (CED) by gender: Amongst the adults with four repeat measures (sample 1) the highest prevalence of CED was observed in Nov-94; nearly one in five (20.5%) had a BMI <18.5. This nutrition situation was classified as 'poor'. There was a significant association between gender and the prevalence of CED in Nov-94 (p=0.008). Approximately, two-thirds (60.0%) of the adult population diagnosed as CED were male. Men were 3.3 times more at-risk of being diagnosed as CED compared to women in Nov-94. The odds risk ratio or prevalence of CED amongst males (39.1%) was 4.7 times higher than that observed amongst women (12.0%). When disaggregated by gender, the nutrition situation was considered 'serious' amongst men and 'moderate to poor' amongst women (Table 6.4.1). Concurrently, at the other end of spectrum women exhibited a high degree of over-nourishment in Nov-94, nearly one in three (30.0%) women were being classified as overweight or obese. Also, the association between gender and the degrees of underweight and overweight was just significant (p=0.050) (Table 6.4.2 and Figure 6.18).

The effect of season on the CED prevalence rate was analysed using McNemar's test of symmetry which measures whether, in repeat rounds of measurement, the change in one direction (positive or negative) is equal to the change in the other direction (negative or positive). During the *pre-harvest season* the rate of CED decreased significantly (p=0.003); over half (53.3%) the adults diagnosed as CED in Nov-94 were classified as adequately nourished in Mar-95. Subsequently, the prevalence of CED in Mar-95 declined to 9.6%, the lowest incidence rate of CED observed throughout the year (Figure 6.17). The relative risk ratio or incidence of CED decreased by half, being 0.5 times lower in Mar-95 compared with Nov-94. Over the *pre-harvest* period the incidence of overweight amongst women also increased by a fifth to 36.0%; of these a third (12%) exhibited obesity grade II or above. Figure 6.16 illustrates clearly this significant shift of the whole BMI distribution towards the right, with an increase in the incidence of over-nourishment and subsequent decrease in the prevalence of CED. The disparity in the odds risk ratio or prevalence of CED between the genders was most stark in Mar-95, men were 17.3 times more at risk of being diagnosed CED than women (Table 6.4.1; Figure 6.19).

Usually, the *pre-harvest* period is associated with food scarcity and increased energy demands and is known in Zimbabwe as the *'hungry'* season. Unexpectedly during the 1994/95 *pre-harvest* period the prevalence of CED decreased significantly and the prevalence of overweight and obesity increased substantially. The uncharacteristic seasonal change in adult nutritional status maybe partially explained by a series of exceptional circumstances that occurred during the study. The 1994/5 agricultural harvest was declared a disaster in Mar-95; this coincided with national level political elections. The distribution of food relief to the worst affected drought areas including Buhera District, was prompt and adequate.

In contrast, during the *harvest* period a time generally associated with optimal nutritional status the prevalence of CED amongst adults in longitudinal sample 1 increased 2.7% to 13.7%. The risk ratio of adult under-nourishment was 1.4 times higher than that observed in Mar-95; this change in prevalence of malnutrition was statistically insignificant. Although, the odds risk ratio of CED for men compared to women decreased substantially from 17.2 to 12.7 times, the association between gender and CED remained highly significant (p=0.001) (Table 6.4.1 and Figure 6.20). Over the *post-harvest* the overall prevalence of CED continued to gradually increase rising another 2.7% to 16.4% in Nov-95; this increase was statistically insignificant. As the incidence of CED increased generally within the population the gender gap of CED decreased further but remained highly significant (p=0.004); men were 6.1 times more likely to be diagnosed CED compared to women (Table 6.4.1 and Figure 6.21).

6.4.3 Seasonal variation in prevalence of Chronic Energy Deficiency (CED) by discrete periods of adulthood: The larger combined longitudinal sample (n=318) was used to examine the seasonal pattern of CED between and within age groups by gender (Tables 6.4.3-6.4.10). There was a significant association between the seasonal prevalence rates of CED and the three discrete periods of adulthood throughout the year. The prevalence rates of CED amongst the elderly were significantly higher than their younger counterparts consistently throughout the agricultural cycle. One in four elderly were diagnosed as CED in Mar-95, decreasing to one in five in Jul-95, increasing to one in four in Nov-95. Within the elderly population men were most at-risk; the prevalence rate of CED was seriously high for elderly men ranging between 29.7-37.8% during the year compared to 13.2-18.4% observed amongst their female counterparts. These results suggest that one in three elderly men were diagnosed CED compared to one in five to one in seven elderly women. These gender differences in the prevalence rates of CED within the elderly population were only statistically significant during the *post-harvest* month Nov-95 p=0.031 (Table 6.4.9). These incidence rates suggest elderly women were most vulnerable during the *pre-harvest* month (Mar-95) and elderly men were most at-risk during the *post-harvest* month (Nov-95).

Young adults were consistently diagnosed as the second most nutritionally at-risk age group within the adult population. However, due to the relatively small sample of young adults (n=31) and the difficulties associated with using a BMI of 18.5 to denote thinness within this age group these results should be interpreted with caution. One in six to one in eight young adults were categorised as CED during the year; the highest prevalence of CED was observed in Mar-95 the *pre-harvest* month. The gender difference in prevalence rates of under-nourishment were pronounced throughout the year peaking during the *harvest* period (Jul-95) when one in four men were classified as CED and no women in this age group was diagnosed as under-nourished. Figure 6.23 illustrates the distinct gender disparity of the BMI distribution; the majority (92.9%) of women were diagnosed as adequately nourished and a small proportion (7.1%) were classified as either mildly undernourished or overweight. In comparison, the BMI distribution of young male adults was distinctly shifted to the left. Approximately three-quarters of the young male adults were considered adequately nourished, 0-5.9% considered severely malnourished, 5.9%-11.8% were diagnosed as moderately thin and 5.9-17.6% were mildly thin throughout the year. No young male adult was diagnosed as over-nourished.

Amongst the middle-aged population the overall seasonal prevalence of CED was low ranging between 4.7-9.0% or one in twenty-two to one in eleven. Within both the male and female population the middle-aged were the least nutritionally vulnerable. Amongst this age group the prevalence of CED increased sequentially throughout the year. The lowest prevalence of CED was observed in the *pre-harvest* month (Mar-95) and the highest in the *post-harvest* month (Nov-95). Moreover this was attributed to the fluctuations in female nutritional status rather than that of males for whom the prevalence of CED was fairly consistent throughout the year. Within the middle-aged population there was a significant association between gender and the prevalence of CED in each period of the agricultural cycle Mar-95 $p<0.001$, Jul-95 $p<0.001$ and Nov-95 $p<0.001$ (Table 6.4.7). Similarly, there was a highly significant association between gender and the distribution of the BMI spectrum amongst the middle-aged population throughout the year whereas the association was statistically insignificant for the young (Table 6.4.5) and elderly population (Table 6.4.9). The BMI distribution of middle-aged males was principally negatively skewed conversely the female BMI distribution was overtly positively skewed.

These results verify that adults were most at-risk of CED in November a time of food scarcity and high demand for labour during the agricultural cycle. Adults were least at-risk of CED in March the end of the *pre-harvest* period. This pattern of seasonal incidence of CED prevailed for both genders. As highlighted in the cross-sectional sample, men were at significantly higher risk of CED than women throughout the year as were the elderly population compared to younger adults and the middle-aged.

6.4.4 Association between initial nutritional status and prospective weight change:

Results of previous empirical work conducted in similar chronically nutritionally insecure environments have shown that the degree of oscillation in body weight is determined by previous nutritional status. The association between initial adult nutritional status observed at the start of study (Nov-94) and prospective absolute and relative seasonal weight change was examined for the adult population as a whole and disaggregated by gender. In respect of relatively small sample size and the distribution of BMI, adult nutritional status was categorised into one of three groups: malnourished (BMI <18.5), adequately nourished (BMI 18.5-24.99) and over-nourished (BMI ≥25.0). Repeated measures ANOVA was conducted using nutritional status observed in Nov-94 as the between-subject effect and age as a covariant. No significant within-subject or between-subject effect related to initial nutritional status was observed. However, there was a distinct trend observed in each of the three seasons. During the *pre-harvest* period the overweight/obese had the highest absolute weight gain 2.7 kg whereas the CED had the lowest absolute weight gain 1.9 kg. However, when the *pre-harvest* weight differences were expressed relative to the previous body weight the linear association between initial nutritional status and the seasonal change in relative weight changed direction. The 1.9 kg and 2.7 kg absolute weight increases were equivalent to 4.2% and 3.8% relative body weight increases, respectively. During the *harvest* period the adults diagnosed as CED at the outset of the study in Nov-94 were the most protected exhibiting a positive gain in weight of 0.3 kg equivalent to 0.8% increase. In contrast, the adequately and over-nourished on average lost weight. During the *post-harvest* period all three categories of nutritional status lost weight, the overweight/obese exhibiting the highest absolute weight loss, -2.0 kg which was equivalent to a relative seasonal decrease of 2.4%. The adequately nourished presented the least absolute and relative weight loss (-1.3 kg, -2.2%). Although, the CED did not present the highest absolute weight loss in the *post-*

harvest season when the amount lost was expressed in relative terms, the relative amount lost (-2.8%) was actually higher than the relative weight lost by adequately nourished and overweight or obese population (Table 6.4.11).

ANCOVA was used to examine the association between initial nutritional status and inter-annual absolute and relative weight change. Adults diagnosed with CED at the outset of the study faired the best during the drought. After controlling for age the adults diagnosed as CED at the start of the study gained the most weight (0.94 kg) equivalent to 2.2% of their initial body weight, the adequately nourished gained 0.40 kg or 0.8% initial body weight whereas the over-nourished exhibited minimal year on year variation in weight gaining 0.03 kg equivalent to 0.2% positive change in body weight (Table 6.4.12).

Using the larger longitudinal sample 2 of adults the relationship between baseline nutritional status observed in Mar-95 and prospective weight change during the *harvest* and *post-harvest* periods was examined for the whole spectrum of nutritional status. Nutritional status in Mar-95 was categorised into five groups: severe/moderate CED (BMI <17.00) mild CED (BMI 17- <18.5), adequate nourishment (BMI 18.5 - 24.99) and overweight (BMI: 25-29.99) and obesity grade II-III (BMI ≥30). Although, the sample sizes were small within each category of nutritional status a significant linear trend was observed during *harvest* period (p=0.006) (Table 6.4.13). After controlling for age the severe/moderately malnourished gained the most weight followed by the mildly malnourished, the adequately nourished and overweight; all exhibited a positive change in weight whereas the obese lost weight. During the *post-harvest* period adults of all degrees of nourishment lost weight; there was no significant difference or pattern in the amount of weight lost in relation to baseline nutritional status in Mar-95. On average adults diagnosed as mildly CED in Mar-95 were the most protected and the overweight the least protected (Table 6.4.13).

6.5 Seasonal changes in child nutritional status

The seasonal change in child nutritional status was also examined in the whole group and separately by the three discrete periods of growth: pre-school years, middle childhood and adolescence. Absolute and relative mean height, weight and MUAC increments and the difference in Z-scores for HA, WH, WA and BMI for age were used to assess the impact of seasonality on child growth performance. In this section detailed statistical analyses are not discussed since they are repeated techniques used in sections 6.1-6.4. Rather an attempt has been made to provide a summary of results.

6.5.1 Sample characteristics: this section describes gender and age distribution of the longitudinal child samples and evaluates their representativeness.

Child longitudinal sample 1: with four repeat measures included 188 children aged <18 years; this sample was approximately equally distributed by age group. A total of 55 (29.3%) of the sample were pre-school children (<5 years), 73 (38.8%) were primary school children (5-9.99 years) and 60 (31.9%) were adolescents (10-17.99 years). There was an overall distinct female bias for the whole child sample and within each age group. The ratio of females to males for pre-school, primary school aged children and adolescents was 1.3, 1.2 and 1.5, respectively. Females were significantly younger than the males within the pre-school (t=2.268, p=0.028), and adolescent (t=2.149, p=0.034) populations. Amongst primary school age group, females were slightly older than males although the age difference was statistically insignificant.

Child longitudinal sample 2 with three repeat anthropometric measures was nearly three times larger than sample 1 consisting of 546 children. The age and gender distribution was similar to the overall demographic profile of the child study population described in Chapter 4. The female bias observed in longitudinal sample 1 was less pronounced in sample 2 for the whole child sample and within age groups. The ratio of females to males for pre-school children, primary school aged, and adolescents was 1.1, 1.04 and 0.9, respectively. Approximately, a quarter (23.4%) of the child longitudinal sample 2 was of pre-school age (n=128), a third (33.3%) were of primary school age (n=182) and (43.2%) were adolescents (n=236). The gender differences in the mean age of pre-school, primary school-aged children and adolescents were all statistically insignificant.

6.5.2 Evaluation of the representativeness of the longitudinal samples - child: A comparison of the demographic composition, anthropometric measures and indicators between the two longitudinal samples and the cross-sectional sample of children who had been measured on at least one occasion but had participated less than three times were carried out to test for significant differences between the three samples by survey round. The results of the series of one-way ANCOVA models used to examine the sample effect after controlling for age differences are summarised by age group in Appendix 4-Tables 6.5.1-6.5.8. The significant differences observed in the anthropometric measures and indicators between the longitudinal samples and each respective cross-sectional sample were predominately caused by age differences. These age differences are partially attributed to study design. Age group at the time of recruitment, rather than age group at the time of each measurement was used to avoid changes of the demographic profile of the respective longitudinal samples. After controlling for age there was limited sample effect on the mean anthropometric measures and indicators or prevalence rates of malnutrition. In all cases where significant differences were observed, the variance was between the two longitudinal samples and the respective cross-sectional samples. No significant difference was observed between the two longitudinal samples for all age groups, anthropometric measures and indicators in all survey rounds suggesting that they could be merged together.

6.6 Seasonal changes in repeated child weight measures

The seasonal variation in 4-monthly absolute and relative weight increments were examined for the whole child longitudinal sample 1 (n=188) by age group and gender. A series of repeat analysis of variance were subsequently carried out separately for each period of childhood to examine the within and between-subject effect of gender amongst the pre-school, primary school and adolescent population on the four repeat weight measures and three 4-monthly seasonal weight increments. In each analysis age was entered as a co-variate to control for the higher growth velocities observed during infancy and adolescence and gender was included as a between-subject effect. Using the relatively larger longitudinal sample 2 (n=734) with three rounds of weight measures, yearly age classes and gender were concurrently used as between-subject factors to examine if younger or older members were affected by seasonality differently.

6.6.1 Within and between-subject effect of gender on seasonal absolute and relative weight gains for whole child population: Repeated measures analysis was used for the whole child population using age group and gender as the two between-subject factors. The results of the three 4-monthly seasonal absolute (kg) and relative (%) estimated mean weight increments computed for the *pre-harvest*, *harvest* and *post-harvest*, respectively are summarised by age group and gender in Tables 6.6.1-6.6.2. The computed absolute (kg) and relative (%) annual weight velocities are presented by gender and age group for the whole population in Tables 6.6.3-6.6.5.

The longitudinal child sample 1 (n=188) with four repeat weight measures on average gained weight over all three seasons. The absolute and relative amount of weight gained in each season varied significantly for the whole child population ($p<0.001$) (Table 6.6.1). Overall, *pre-harvest* weight gain (1.23 ± 0.9 kg) was significantly larger than the weight gain in the *harvest* period (1.00 ± 0.8 kg) ($F=4.960$, $p=0.027$). The weight gain observed during the *post-harvest* period (0.35 ±1.0 kg) was significantly smaller than the amount gained during the *harvest* period ($F=36.465$, $p<0.001$) (Table 6.6.1). The seasonal pattern and incremental gain in weight by gender were similar. In contrast, weight gains varied significantly by age group. Overall adolescents, on average gained significantly more weight than both the pre-school ($p<0.001$) and school-aged populations ($p<0.001$).

6.6.2 The relationship between seasonal weight gain and age for the whole child population: Regression analysis was used to examine the association between age and seasonal weight increments further these are presented in Appendix 4- Tables 6.6.64-6.6.68. A highly significant curvilinear relationship was observed between *pre-harvest* weight velocity and age (p=0.001) (Table 6.6.64 and Figure 6.38). On average pre-school weight gain during the *pre-harvest* season (0.89 ± 0.9 kg) was 1.3 times less than primary school weight gains (1.17 ± 0.9 kg) and approximately half the amount of weight gained by adolescents (1.63 ± 0.9 kg) (Table 6.6.1). In the *harvest* period weight gains across the three age groups were similar, pre-school children (0.95 ± 0.8 kg) gained slightly more weight than primary school aged children (0.88 ± 0.8 kg), adolescents continued to gain the most (1.178 ± 0.8 kg) (Table 6.6.1 and Figure 6.39). In the *post-harvest* period there was a highly significant curvilinear relationship between weight velocity and age (p=0.014). The negative age, positive quadratic and negative cubic coefficients depict the smaller weight gain observed amongst the primary school population (0.16 ± 0.8 kg) compared to pre-school children (0.27 ± 0.8 kg) and adolescents (0.65 ± 0.8 kg) (Figure 6.40). After controlling for age there were no significant gender effect observed during the *pre-* and *post-harvest* periods whereas during the *harvest* period girls on average gained 0.247 kg more than boys of the same age, a gender difference which was just significant (p=0.045) (Table 6.6.64).

6.6.3 The pre-harvest, harvest and post-harvest seasonal contribution to total annual weight increment: The distinct sequential downward spiralling seasonal pattern of child weight velocity during the 1994/5 agricultural cycle was particularly evident when the three 4-monthly weight increments were subsequently expressed as a percentage of the total annual weight velocity. The *pre-harvest*, *harvest* and *post-harvest* season contributing 47.5%, 38.9% and 13.6% of the total annual weight increment, respectively.

Overall, this seasonal pattern prevailed for both genders, but the oscillation in male seasonal weight gains were more prominent than their female counterparts (Figure 6.26). Boys accumulated over half (51.8%) or (1.26 ± 0.9 kg) their total annual weight gain during the *pre-harvest* period, just over a third (36.1%) or (0.87 ± 0.8 kg) in the *harvest* period and an eighth (12.1%) or (0.30 ± 1.0 kg) during the *post-harvest* period. In contrast, the *pre-harvest* and *harvest* weight gains for female children were fairly similar accounting for 43.6% and 41.4% of their total annual weight gain, respectively or (1.19 ± 0.9 kg) and (1.13 ± 0.8 kg). The remaining sixth (15%) (0.41 ± 1.0 kg) of the female annual weight gain was amassed during the *post-harvest* period (Table 6.6.1).

The slight variation in the pattern of seasonal weight gain observed by age group was also made clearer when the seasonal weight increments were expressed as a percentage of the total annual weight velocity (Figure 6.27). The older age groups, namely primary school children and adolescents followed the general seasonal pattern of weight gain established for the whole child population exhibiting their highest weight gains during the *pre-harvest* period. In contrast, the pre-school children on average gained slightly more weight during the *harvest* period. In the *pre-harvest* period on average the pre-school population gained 41.9%, adolescents gained nearly half (47.4%) and primary school population accumulated more than half (52.8%) their total annual weight velocity. In contrast during the *harvest* period the pre-school population gained 44.9% and the primary school and adolescent population gained just over a third, (39.9%) and (34.4%), of their total annual weight increment, respectively. In the *post-harvest* period, the primary school population accrued only 7.3% of their total annual weight increment, the pre-school population gained 13.2% and adolescents gained 18.2%. This analysis not only highlights the lack of synchronisation in weight gain between the pre-school population and the older age groups but also emphasises the pronounced fluctuation in seasonal weight gains particularly amongst the primary school-aged population.

6.6.4 Annual absolute and relative weight velocity by gender and age group: One-way ANCOVA was used to compare the overall annual weight velocity by gender for the whole child population. After controlling for age the estimated mean annual weight velocity for male and female children was 2.38 ± 1.3 kg and 2.75 ± 1.3 kg, respectively, the 0.373 kg gender difference was just statistically significant (p=0.045) (Table 6.6.3). These absolute weight gains were expressed relatively, as a percentage of initial body weight observed at the start of the study in Nov-94. After controlling for age, boys had accumulated an additional 10.5% and girls amassed 12.3% more of their initial weight measured in Nov-94, the 1.8% gender difference was highly significant (p=0.020) (Table 6.6.3). These results suggest that after controlling for age female children gained significantly more absolute (kg) and relative (%) weight during the 1994/5 agricultural cycle compared to their male counterparts.

Comparisons by age group indicated the annual weight velocities of the pre-school, primary school and adolescent populations were 2.1 ± 0.8 kg, 2.2 ± 0.9 kg and 3.5 ± 1.8 kg, respectively. The between-subject effect of age group was highly significantly (p<0.001) (Table 6.6.4). Adolescents gained significantly more weight over the year than the pre-school and primary school population, whereas the difference in the estimated mean annual absolute weight velocity between the two younger age groups was statistically insignificant. However, when the observed annual absolute weight increment was expressed relatively as a percentage of initial body weight observed in Nov-94, the reverse pattern was observed (Table 6.6.5).

6.6.5 Within and between-subject seasonal variation of weight increments amongst the pre-school population: A significant seasonal weight variation was found amongst the pre-school sample (p<0.001). *Pre-harvest* and *harvest* weight gains were significant but little or no *post-harvest* effect. In the *pre-harvest* season boys gained significantly more weight than girls (F=5.260, p=0.026) and during the *harvest* period girls gained 0.579 kg more weight than boys (F=10.055, p=0.003). The pronounced gender difference in the seasonal pattern of weight gain and the amount accrued are clearly evident in Figures 6.29 and 6.35.

To examine the interaction and association between pre-school seasonal weight velocities and age further, age was regressed on the absolute weight increments. In the *pre-harvest* season there was a significant inverse linear relationship observed between weight velocity and age, suggesting that with each year of age the 4-monthly weight increment was -0.255 kg less ($p<0.001$). After controlling for the linear effect of age the gender effect remained significant ($p=0.026$), the negative coefficient substantiating the notably lower *pre-harvest* female weight gain; on average girls gained -0.409 kg less than males of the same age (Table 6.6.65). In contrast, during the *harvest* season the reverse pattern was observed, the linear association with age was less pronounced and positive suggesting that older children gained more weight. After controlling for the linear effect of age girls amassed significantly more weight than boys of the same age over the *harvest* period approximating to 0.579 kg ($p=0.003$) (Table 6.6.65). Whereas during the *post-harvest* period the association between weight velocity and age or gender were statistically insignificant suggesting that on average the gain in weight was similar across both sexes and throughout the pre-school age-span (Tables 6.6.4, 6.6.7 and 6.6.65).

6.6.6 Annual absolute and relative weight velocity by gender and age group amongst the pre-school population: No significant gender or age group differences in annual weight velocity amongst the pre-school population were found. The overall adjusted mean annual weight velocity of pre-school male and female children was 2.09 ± 0.8 kg and 2.16 ± 0.8 kg, respectively. The two younger age groups exhibited significantly higher relative weight gains compared with children aged 2, 3, and 4 years old. Infants (<1 year) and children in their first year of life amassed 30.2% and 22%, of the initial body weight, respectively. In comparison children aged 2, 3, and 4 years old gained 13.4%, 13.4% and 12.4% of the initial body weight, respectively (Table 6.6.17).

6.6.7 Within and between-subject seasonal variation in weight gain amongst primary school-aged population: There was significant within-subject seasonal variation in weight over the four time periods ($p<0.001$) due to the greater weight gain (0.88 ± 0.6 kg) observed in the *harvest* period only ($F=15.729$, $p<0.001$) (Tables 6.6.9). The significant heterogeneity observed between the three seasonal weight increments ($p=0.030$) was solely attributed to the poor *post-harvest* weight velocity which was significantly lower than the *harvest* weight increment (F=6.253, p=0.015) (Table 6.6.10). The pattern and degree of oscillation in seasonal weight gains varied slightly by yearly age classes (Table 6.6.15). However, regressing age on each of the 4-monthly weight gains failed to illuminate a significant linear or curvilinear pattern of weight gain across the age-span of the primary school-aged population (Table 6.6.67).

6.6.8 Annual absolute and relative weight velocity by gender and age group amongst the primary school-aged population: No significant gender or age differences in annual weight velocities were apparent. Male and female primary school-aged children gained 2.17 ± 0.9 kg and 2.27 ± 0.9 kg, respectively. These absolute weight gains were equivalent to relative male and female weight gains of 9.5-10.0% (Table 6.6.11). The annual amount gained by yearly age classes varied by less than half a kilogram ranging between 1.98-2.39 kg. These absolute weight gains were equivalent to relative weight gains of between 7.8-11.4% (Table 6.6.17).

6.6.9 Within and between subject seasonal variation in weight gain within the adolescent population: No significant seasonal variation in weight gains were found amongst the adolescent age group (Table 6.6.12). Although, the seasonal pattern and amount of weight gained by male and female adolescents were comparable there were significant differences in the seasonal weight gains across the adolescent age-span (p=0.002) (Table 6.6.12). Children aged 10 and 15 years showed highest weight gains during the *harvest* period whereas in children aged 11-14 years old and 16-17 years the highest weight increments occurred during the *pre-harvest* period (Table 6.6.15). There was limited association between age and weight velocity with one exception during the *pre-harvest* period a significant positive linear relationship was observed indicating that adolescents gaining 0.237 kg more during this season with each year of life (p=0.002) (Table 6.6.68).

Male adolescents generally exhibited more oscillation in their weight gain compared to their female counterparts. As Figures 6.31 and 6.37 illustrate boys gain half (50.2%) their annual weight increment during the *pre-harvest* period, a third (33.8%)

during the *harvest* period and only a sixth (16.0%) over the *post-harvest* period. In comparison, the seasonal weight gains of girls were more consistent with *pre-harvest*, *harvest* and *post-harvest* weight increments contributing 45.2%, 34.8% and 20.0%, respectively, of the total annual female weight velocity.

6.6.10 Annual absolute and relative weight velocity by gender and age group amongst the adolescent population: No significant gender differences in annual weight velocities were found. Annual absolute weight gains varied by age amongst adolescents (p=0.034) (Table 6.6.14). Age classes experiencing pubescence exhibited the largest absolute weight gains (Table 6.6.17).

6.6.11 Within and between-subject seasonal variation in height increments for the whole child population: No within-subject effects were observed with the *pre-harvest*, *harvest* and *post-harvest* absolute height gains of 1.77cm, 1.95 cm and 1.78 cm, respectively (Table 6.6.18). Approximately, a third of the total annual height velocity was gained in each season, illustrating the consistent nature of height velocity. The pattern of male and female height gains differed significantly between the *pre-harvest* and *harvest* seasons (F=4.792, p=0.030). Female children exhibited their highest absolute incremental height gain during the *pre-harvest* period whereas males presented their largest height gain during the *harvest* period. It is evident that after disggregating the child population by age group the gender disparity in the seasonal pattern of height gain prevailed amongst pre-schooler's only (Table 6.6.18).

The average 4-monthly incremental gain in height varied significantly by age group (F=64.852, p<0.001) and by gender (F=3.410, p=0.035). Overall mean 4-monthly height gain of pre-school children (2.54 ± 0.6 cm) was significantly greater than both the primary school-aged (1.56 ± 0.6 cm) (p<0.001) and adolescent populations (1.40 ± 0.6 cm) (p<0.001). The mean 4-monthly height velocities of females (1.94 ± 0.6 cm) were significantly larger than males (1.72 ± 0.6 cm).

6.6.12 The relationship between seasonal height gain and age for the whole child population: Figures 6.41-6.43 clearly depict the relationship between the seasonal height velocities and age for the whole child population. During the *pre-harvest* and *post-harvest* periods there was a highly significant curvilinear relationship (Table 6.6.64). In contrast, over the *harvest* period there was an inverse relationship between age and the gain in height suggesting that with each year of life the amount of height gained was -0.097 cm less ($p<0.001$) (Table 6.6.64). For the whole child population the gender effect was significant in the *pre-harvest* period only and remained so after controlling for the effects of age, with girls gaining 0.445 cm more height than males of the same age ($p=0.014$) (Table 6.6.65).

6.6.13 Annual absolute and relative height velocity by gender and age group: After controlling for the curvilinear effect of age, the 0.26 cm gender difference in the annual height velocity was statistically insignificant (Table 6.6.20). In contrast, the age group effect was highly significantly ($p<0.001$) (Table 6.6.21). The overall annual absolute mean height velocity of the pre-school population (7.63 ± 1.8 cm), was 1.6 times greater than the mean annual height increment of the primary school-aged population (4.68 ± 1.7 cm) and 1.8 times greater than the mean annual height velocity of the adolescent population (4.19 ± 1.8 cm). The Games-Howell *a posterior* test indicated that the pre-school population gained significantly more height over the year than the primary school and adolescent populations, whereas the annual height velocities of the two older age groups were similar and statistically insignificant. On average the pre-school children, primary school-aged population and adolescents accumulated 9.2%, 4.0%, and 3.0% more of their initial body height. The relative height gain of the pre-school population was significantly higher than both primary school and adolescent populations ($p<0.001$) (Table 6.6.22).

6.6.14 Within and between-subject seasonal variation in height velocities amongst the pre-school population: A significant within-subject effect between the three height increments ($p=0.002$) (Table 6.6.23). The estimated mean *pre-harvest* height increment (2.71 ± 1.7 cm) was significantly larger than the *harvest* (2.49 ± 1.5 cm) height gain (F=8.582, p=0.005), whereas the 0.03 cm difference between the *harvest* and *post-harvest* height increments was statistically insignificant. The seasonal pattern of height velocity varied significantly across the pre-school age-span (p=0.002) (Table 6.6.23). The within-subject contrasts indicated that the significant heterogeneity by age was attributed to the differences between the *pre-harvest* and *harvest* height increments only (F=8.996, p=0.004). After controlling for age the between-subject effect of gender was statistically insignificant (Table 6.6.23). Regressing age on the pre-school population height velocities illuminated a significant curvilinear pattern in the *pre-harvest* and *post-harvest*; in each case the pattern of the higher order effect of age was similar. The negative age and positive age^2 and negative age^3 depicting the relatively larger post-natal incremental height gains of infants <1 year (Table 6.6.65).

6.6.15 Annual absolute and relative height velocity by gender and age amongst the pre-school population: Regression analysis revealed a highly significant curvilinear association between age and annual height increment amongst the pre-school population (p<0.001) (Table 6.6.65). The cohort of infants exhibited the largest annual incremental gain in height. On average infants gained 13.2 ± 1.5 cm equivalent to 21.9 ± 2.3% of their baseline Nov-94 height measure. The infants absolute and relative annual incremental height velocity were approximately double the respective annual height increments observed amongst the cohort of 1-4 year olds. (Table 6.6.34). After controlling for the age effects the mean annual absolute height increments of male and female pre-schooler's were similar (Table 6.6.25).

6.6.16 Within and between-subject seasonal variation in height velocities within the primary school population: The results of the within-subject contrasts used to compare the four repeated height measures serially highlighted that there was significant gain in height over the *pre-harvest* (1.34 ± 0.9 cm) (F=22.508, p<0.001), *harvest* (1.82 ± 0.9 cm) (F=18.752, p<0.001) and *post-harvest* (1.53 ± 0.7 cm) (F=13.098, p=0.001) seasons (Table 6.6.26) whereas the within-subject contrast test for the interaction between height measures and age suggested that there was a significant difference in the *pre-harvest* period only (F=6.767, p=0.011). Similarly, the regression analyses identified a significant inverse linear association between age and *pre-harvest* height gains predicting that the amount gained was -0.20 cm less with each year of age (Table 6.6.67). The within-subject effect comparing the three 4-monthly seasonal incremental gains in absolute or relative height were both statistically insignificant (Table 6.6.25). This result suggests that there was limited seasonal variation between the *pre-harvest*, *harvest* and *post-harvest* seasonal height increments; the estimated mean contribution of each season to the total annual height velocity was 28.6%, 38.8% and 32.6%, respectively (Figure 6.28). Within the primary school-aged population, the distribution of the seasonal height increments of males was less uniform, exhibiting a slightly higher level of fluctuation compared with their female counterparts (Figures 6.30 and 6.36).

6.6.17 Annual absolute and relative height velocity by gender and age amongst the primary school-aged population: The annual height velocity varied significantly across the age-span of the primary school-aged population (p=0.001) (Table 6.6.28). Regressing age on the annual absolute height velocity revealed a significant inverse linear association (p=0.011) (Table 6.6.67). For every increase in age by one year within the primary school age group the annual incremental gain in height was predicted to be -0.31 cm less. No significant gender differences were found (Table 6.6.28).

6.6.18 Within and between-subject seasonal variation in height velocities within the adolescent population: There was significant heterogeneity in height gains in all three seasons. Overall, the lowest estimated mean height increment (1.31 ± 1.0 cm) was observed during the *pre-harvest* period (F=9.419, p=0.003), and the highest (1.56 ± 10.9 cm) during the *harvest* period (F=32.452, p<0.001). Height velocity (1.38 ± 1.0 cm) during the *post-harvest* period was similar to that observed during the *pre-harvest* period (F=32.698, p<0.001) for the adolescent population (Table 6.6.29). Incremental height velocities over the *pre-harvest*, *harvest* and *post-harvest* were similar and lacked significant seasonal oscillations (Table 6.6.30). Male adolescents presented more fluctuation in their seasonal height gains compared to their female counterparts (Figure 6.6.31 and 6.6.37).

6.6.19 Annual absolute and relative height velocity by gender and age amongst the adolescent population: The annual height velocity varied significantly across the age-span of the adolescent population (p=0.001) (Table 6.6.31). For every increase in age by one year within the adolescent age group the annual incremental gain in height was -0.555 cm less (Table 6.6.67). The cohort of 10, 11 and 12 year olds at the start of the study exhibited the highest estimated mean annual incremental gain in height (Table 6.6.34). After controlling for age, the 0.63 cm gender difference in the annual height increment was statistically insignificant (Table 6.6.31).

6.6.20 The relationship of seasonal height velocities to seasonal weight velocities: Some empirical studies have indicated a lagged effect with height velocities subsequently following weight gains by 3-4 months (Waterlow, 1994). It was not possible to calculate the specific time lag between the weight and height velocities in this study as both measurements were obtained every 4 months. However, there was evidence of a lag, suggested by the lack of synchronisation between the peaks and troughs of the incremental gains in weight and height. Height gains peaked during the *harvest* period following the pronounced *pre-harvest* weight gains. The lagged effect was partially substantiated by the contrasting seasonal pattern of male and female weight and height gains which emerged within the pre-school population. The largest weight gain and smallest height increment was observed during the *pre-harvest* period for boys whereas girls exhibit a similar contrasting pattern of weight and height velocity over the *harvest* period (Figure 6.29).

6.6.21 Evaluation of the adequacy of seasonal weight and height velocities: The adequacy of the seasonal and annual weight and height velocities observed amongst the Buhera child population were evaluated. Each of the observed estimated mean weight and height increments were compared to the 4-monthly and annual expected weight and height increments derived from the NCHS growth reference median for a child of the same month of age and gender[4] using a series of paired *t*-tests (Tables 6.6.35-6.6.36 and Figures 6.44-6.45).

On average the *pre-harvest* weight increments for all three age groups exceeded the expected weight gains derived from the NCHS reference median for children with the same demographic profile. The 0.199 kg difference between the observed and expected *pre-harvest* weight gains amongst the primary school-age population were significantly different (p=0.020) (Table 6.6.35). Over the *harvest* period the under five's continued to exceed the predicted weight gains of the NCHS reference median, the 0.256 kg difference between the observed and expected weight velocity also reached statistical significance (p=0.012) (Table 6.6.35 and Figure 6.44). In contrast, primary school-aged children and adolescents on average gained only 84.9% and 82.6% of the expected 4-monthly weight velocity for their age and gender. In the *post-harvest* period all three age groups gained significantly less weight than expected. The absolute and degree of weight deficit during the *post-harvest* period varied by age group. The absolute incremental difference between the observed and expected was 0.393 kg amongst pre-school children (p<0.001), 0.910 kg amongst primary school children (p<0.001) and 0.780 kg within the adolescent population (p<0.001).

Overall the annual weight velocity attained by pre-school children was very similar to the expected being -0.02 kg or 0.9% lower than that derived from NCHS reference median for pre-school children of the same age and gender distribution. The annual weight velocities exhibited amongst the primary school-aged population were 0.87 kg or 28.8% lower than expected; this difference was statistically significant (p<0.001) (Table 6.6.35). The estimated mean annual weight incremental observed amongst the adolescent population were also significantly lower than expected (p=0.013); the deficit was estimated to be -0.84 kg or 19.5%.

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[4] *The NCHS weight for age and height for age growth reference data was imported into Excel and 4-monthly age and gender specific growth velocities were computed for the whole age range 0-17.99 years. These growth reference velocities were subsequently matched to the observed subjects of the same age and gender.*

In all three seasons the 4-monthly observed height velocity measures were less than expected for all three age groups. The difference between the observed and expected height velocities was statistically insignificant for pre-school population in all three seasons. However, when the three incremental seasonal height deficits were aggregated the mean overall annual growth deficit of -1.01 cm was 11.7% lower than the NCHS reference median and statistically significant (p=0.001) (Table 6.6.36). In contrast, the *pre-harvest* and *post-harvest* height velocities were significantly lower than the 4-monthly height increments derived from the NCHS median for both the primary school and adolescent populations within Buhera. Amongst the primary-school aged population the *pre-harvest* and *post-harvest* deficits were estimated to -0.55 cm and -0.41 cm, respectively. In comparison, the *pre-harvest* and *post-harvest* mean height velocity deficits for adolescents were estimated to -0.46 cm and -0.30 cm, respectively. The accumulated annual incremental height deficit between the observed and expected was similar for both the primary school-aged (-1.03 cm or 18.1%) and adolescent (-0.92 cm or 18.0%) populations. In both cases they were significantly less than the annual height velocities derived from the NCHS median with a comparable demographic profile (Table 6.6.36).

6.6.22 Within and between-subject seasonal variation in MUAC velocities amongst the whole child population: There was a significant within-subject effects (p<0.001) (Table 6.6.37) and the two pairwise comparisons indicated that there was a significant difference between the estimated mean change in MUAC over the *pre-harvest* period which was slightly negative (-0.078 ± 0.7 cm) and positive change that occurred over the *harvest* period (0.270 ± 0.6 cm) (F=16.101, p<0.001), whereas the estimated mean gain in MUAC observed during the *post-harvest* (0.275 ± 0.7 cm) period was similarly to the *harvest* period.

A paired t-test comparing the initial and final MUAC measure indicated that the 0.46 cm annual gain in mean MUAC for the whole child population was highly significant (t=7.327, p<0.001) and remained so correcting for age (p=0.033). The female mean annual incremental gain in MUAC (0.574 ± 0.8 cm) was significantly larger than that observed amongst males (0.312 ± 0.8) (p=0.033) (Table 6.6.38). Similarly, the equivalent relative annual change in the male (2%) and female (3.7%) MUAC were also statistically significant (p=0.025) (Table 6.6.38). The absolute and relative incremental gains in mean MUAC by age group were statistically insignificant (Tables 6.6.39-6.6.40).

6.6.23 Within and between-subject seasonal and annual variation in MUAC velocities amongst the pre-school population: Significant within-subject difference were found (p=0.002) (Table 6.6.41) No obvious seasonal trend was observed by the pairwise comparisons (Table 6.6.42). Highly significant by gender differences were apparent (F=7.588, p=0.009) particularly over the *post-harvest* period (Table 6.6.42 and Figure 6.32).

The annual gain in mean MUAC (0.59 ± 1.0 cm) of pre-school children was highly significant (Paired t-test: t=4.141, p<0.001). However, after controlling for age the gender effect was statistically insignificant (Table 6.6.43). There was a highly significant inverse linear relationship suggesting that with each year of life the annual gain in MUAC was 0.247 cm less (p=0.031) (Table 6.6.66).

6.6.24 Within and between-subject seasonal and annual variation in MUAC velocities amongst the primary school population: Unlike the pre-school population the overall within-subject seasonal variation in MUAC was statistically insignificant for the whole primary school sample as was the within-subject interaction between the seasonal variation in MUAC and age and gender (Table 6.6.45). The slight negative change in mean MUAC observed over the *pre-harvest* (-0.098 cm), was significantly compensated by the positive *harvest* (0.319 cm) and *post-harvest* (0.096 cm) increases, resulting in a highly significant positive intra-annual change (t=3.918, p<0.001). The annual gain in the male and female mean MUAC measure were comparable (Table 6.6.46).

6.6.25 Within and between-subject seasonal and annual variation in MUAC velocities amongst the adolescent population: The notable difference between the adolescent population and the two younger age groups was the pronounced decline in mean MUAC (-0.126 ± 0.6cm) over the *pre-harvest* period which was statistically significant (F=6.244, p=0.016) (Table 6.6.48). No significant gender differences were found (Table 6.6.48). The annual change observed in adolescent mean MUAC (0.51± 0.8 cm) was statistically significant (t=4.738, p<0.001) mirroring the notable annual weight gain observed within this age group.

6.6.26 The association between seasonal changes in MUAC and weight: Advocating the use of MUAC to monitor the nutritional situation is dependent on its sensitivity to change in weight independent of linear growth. Bivariate correlation analysis elucidated a concurrent highly significant moderate positive linear relationships between *pre-harvest* (r=0.366, p<0.001), *harvest* (r=0.282, p<0.001) and *post-harvest* (r=0.324, p<0.001) changes in MUAC and weight for the whole child population (Table 6.6.51). The significant simultaneous changes in body weight and MUAC prevailed across each season within each of the three discrete periods of childhood albeit with a couple of exceptions (Table 6.6.51). Similarly, there was only limited association between the seasonal linear growth velocities and concurrent change in MUAC measure for the whole child population and within each age group (Table 6.6.64). These results suggest that the seasonal incremental changes in MUAC were virtually independent of linear development, more closely reflecting ponderal growth.

6.6.27 Within and between-subject seasonal variation in BMI amongst the whole child population: It is important to remember the nature and subsequent interpretation of seasonal changes in body mass index (BMI) of children is distinctly more complex than adults. The serial BMI measures for adults solely reflects the seasonal variation in body weight. Since, adult stature does not vary, the subject's mean height is related to their successive weight measures. In contrast, the serial BMI measures for children are a composite measure simultaneously reflecting both the seasonal incremental weight and height velocities *per se* and the pattern of weight gain relative to linear growth. Hence, whereas a decrease in mean BMI amongst adults reflects weight loss, a decline in mean BMI amongst children generally reflects the poor gain in weight relative to the incremental gains in linear growth; in both cases the population is getting thinner.

6.6.28 Within and between-subject seasonal and annual variation in BMI amongst the pre-school population: The within-subject seasonal variation in BMI was highly significant (F=4.062, p=0.013) as was between-subject factor of gender (F=3.466, p=0.025) (Table 6.6.55). The notable positive increase in pre-school BMI (0.28 ± 0.9) over the *pre-harvest* period was highly significant (F=7.574, p=0.008) as was the remarkable *post-harvest* decline in mean BMI (-0.50 ± 0.9) (F=4.450, p=0.040) (Tables 6.6.55-6.6.56). The significant divergence in male and female BMI first emerges during the *pre-harvest* period when male BMI increases (0.64 ± 0.9) and females BMI concurrently decreases (-0.09 ± 0.9) (F=8.395, p=0.005) (Table 6.6.56 and Figure 6.32). The significant gender disparity in the oscillation in BMI was sustained over the ensuing *harvest* season when the reverse situation was observed. Female BMI increased (0.68 ± 0.8) directly reflecting their large weight gains relative to the small incremental gain in height. Contrarily, the concurrent negative change in male pre-school BMI (-0.10 ± 0.8) mirrored the minor weight gains compared to the significant incremental height velocity. (F=12.370, p=0.001). Figure 6.32 clearly depicts the gender disparities in the estimated mean change in BMI amongst the pre-school population over the *pre-harvest* and *harvest* seasons and their similarity during the *post-harvest* period. After controlling for the age effect the gender difference in the annual change in mean BMI was statistically insignificant (Table 6.6.57).

6.6.29 Within and between-subject seasonal variation in BMI amongst the primary school-aged population: The within-subject seasonal variation between the four repeat BMI estimates for the primary school-aged population was significant (F=3.322, p=0.021) (Table 6.6.58). Curiously, the within-subject contrasts emphasised the comparatively small positive *harvest* BMI increment as highly significant (F=8.037, p=0.006) rather than the relatively larger positive incremental increase in mean BMI observed over the *pre-harvest* period. This is partially explained by the interactive effect of the co-variate age as the pattern and extent of seasonal difference in mean BMI over the *harvest* period varied significantly across the age-span of the primary school-aged population (F=5.228, p=0.025) (Table 6.6.59). Disaggregating the primary school-aged population by yearly age classes and regressing age on the change in BMI over the *harvest* period unveiled the disparity. There was significant inverse association between age and the estimated mean change in BMI over the *harvest* period; the gain in BMI was -0.085 BMI less with each year of age (p=0.024) (Table 6.6.67). In addition, the serial within-subject contrasts highlighted the general decline in *post-harvest* BMI as highly significant (F=5.607, p=0.021). The descent of the mean BMI over the *post-harvest* period was universal within the primary school-aged population. The decline reverberated across the age-span of both male and female primary school-aged children reflecting the minuscule weight gains. As is evident from Figure 6.33 the pattern of seasonal change in the estimated mean BMI of male and female primary school-aged children were virtually identical throughout the year and statistically insignificant.

6.6.30 Within and between-subject seasonal variation in BMI amongst the adolescent population: There was a significant within-subject seasonal effect observed for the repeated BMI measures of the adolescent population (p=0.011) (Table 6.6.61). This was further confounded by a highly significant interaction between the four repeated BMI measures and age (p<0.001) and gender (p=0.022). These results highlight that additional to the significant seasonal variation there was a further age and gender effect operating across the four rounds of BMI (Tables 6.6.61-6.6.62).

The highly significant between-subject effect of gender highlights the general disparity in male and female ponderal growth. The average female BMIZ (-0.74) based on the four repeat rounds was 0.740 higher than the overall mean BMIZ of males (-1.48) (F=14.019, p<0.001). Intra-annually the slight decline in male BMIZ (-0.051) and the concurrent increase in the female BMIZ (01.46) was nearly significant. (F=3.801, p=0.056) after controlling for the significant linear effect of age on annual change in

BMIZ (F=8.353, $p<0.001$). The results of within and between-subject analysis of gender suggest that on average female adolescents are not only significantly more ponderous but also they faired significantly better in the 1994/5 drought on average gaining weight for height compared to their moderately thin male counterparts who showed signs of becoming leaner.

6.7 Seasonal variation in nutritional status

To assess the impact of the seasonal variation in weight and height velocities on child nutritional status and growth rates, repeated measures analysis of variance was used to determine the pattern and extent of the seasonal digressions in HA, BMI-for-age, WA and WH, Z-scores over the *pre-harvest*, *harvest* and *post-harvest* periods. Positive HAZ, BMIZ, WAZ and WHZ indicate an increased growth rate or weight gain for age whereas negative differences indicate a deceleration in the rate of growth compared to the expected growth reference. The four anthropometric indices derived from international growth reference data (HAZ, BMIZ, WHZ, and WAZ) were analysed using ANCOVA for repeat measures as were the three sets of 4-monthly changes in the four respective indices. The pattern of within and between-subject seasonal differences varied by anthropometric index, age group and gender.

6.7.1 Seasonal variation in nutritional status of the pre-school population:

Adjusted mean seasonal and annual deviation in HAZ, BMIZ, WHZ and WAZ by gender and season for pre-school children aged 0-4.99 years controlling for age are summarised in (Tables 6.7.13-6.7.16 and Figure 6.46). There was also a significant variation in the seasonal changes in HAZ (p=0.008). A slight improvement in linear growth was observed over the *pre-harvest* period this was followed by a subsequent deceleration in linear growth during the *harvest* period, the positive change in mean HAZ over the *post-harvest* period indicated a slight recovery. The positive *post-harvest* and negative *harvest* changes HAZ were significantly different (F=6.876, p=0.011) the pattern and degree of these changes also varied significantly by age (p=0.008). The within-subject contrasts indicated that the overall, HAZ increased slightly 0.012 ± 0.5 during the *pre-harvest* period suggesting a slight improvement in linear growth. The subsequent deceleration in height velocity observed during the *harvest* period amongst the pre-school child population had a significant simultaneous negative impact on the HAZ -0.054 ± 0.4 over the same period ($F=18.401$, $p<0.001$).

Although, the seasonal deviations in male and female HAZ were statistically insignificant it is evident from Figure 6.46 that the pattern varied slightly during the *pre-harvest* period when the pre-school boys linear growth deteriorated by -0.098 HAZ and the girls linear growth improved +0.123 HAZ, whereas during the *harvest* and *post-harvest* periods male and female pre-school children followed the same alternating pattern of significant decrease followed a slight increase in HAZ.

The slight improvement in linear growth observed during the *pre-harvest* period combined with the significant deterioration in linear growth observed during the *harvest* period and the relatively minor recovery of linear growth seen in the *post-harvest* periods resulted in an overall annual deterioration in linear growth for the pre-school population. A paired *t*-test used to compare the initial and final HAZ was statistically insignificant suggesting that the annual deterioration in linear growth was minor (Table 6.7.15). In contrast, the results of one-way ANCOVA examining the gender differences in the annual change in HAZ indicated that the between-subject effect of the co-variate age was highly significant ($p<0.001$). One-way ANCOVA used to examine the annual deviation in HAZ by yearly age classes identified a clear significant division amongst the pre-school population ($F=4.460$, $p=0.004$). The two youngest age classes, infants <1 year and children aged 12-23 months exhibited a deterioration in HAZ whereas children aged ≥2 years showed a slight improvement in linear growth. Hochberg's a *posterior* test indicated that the annual change in linear growth of children aged between 12-23 months was significantly worse than children aged 3 and 4 years old (Table 6.7.25).

After controlling for these age differences, the contrasting patterns of male and female linear growth during the 1994/5 agricultural cycle compounded to have a significant gender difference in the annual HAZ deviation ($p=0.023$) (Table 6.7.16). The estimated mean annual deviation in HAZ was negative suggesting that there was deceleration of the linear growth rate of pre-school boys during the 1994/5 agricultural cycle whereas a positive change in female HAZ indicated a slight improvement in their linear growth rate.

In comparison, the overall within-subject seasonal deviations in WHZ for the whole pre-school population were statistically insignificant whereas the within-subject effect of gender was highly significant ($p<0.001$). This result clearly illustrates the influential impact of the contrasting seasonal weight gains on the WHZ observed between male and female children during the *pre-harvest* and *harvest* period ($F=15.025$, $p<0.001$) and *harvest* and *post-harvest* seasons ($F=8.268$, $p=0.006$) (Table 6.6.13). Overall, the continual and combined improvement in WHZ observed during *the pre-harvest* and *harvest* season were greater than the ensuing deterioration seen in *post-harvest* period resulting in an overall slight but statistically insignificant annual improvement in pre-school weight status for height. The pattern of positive WHZ prevailed for both genders but varied significantly by yearly age classes within the pre-school population ($p<0.001$) (Table 6.7.16). Infants and children aged between 24-36 months both exhibited negative changes in the WHZ, -1.06 and -0.04, respectively. Hochberg's *a posterior* test indicated that deterioration in WHZ were significantly worse than the positive annual WHZ changes observed amongst 1, 3 and 4 year olds. This result suggests that infants and one year olds were relatively more nutritionally at-risk of becoming thinner during the 1994/5 agricultural cycle compared with pre-school children aged 2-4 years olds (Table 6.7.27).

The contrasting gender patterns of weight gain also had a significant impact on the four repeated BMIZ in an identical way as that observed for WHZ (Figure 6.46). The overall within-subject seasonal deviation in BMIZ for the whole pre-school population were statistically insignificant whereas the within-subject effect of gender was just significant ($p=0.045$). The results of the within-subject contrasts used to compare the 4 repeated BMIZ serially using three pairwise contrasts suggested that the change in male and female BMIZ over the *pre-harvest* was significantly different ($F=5.789$,

p=0.021) as was the gender deviation in *harvest* BMIZ (F=6.328, p=0.016) directly reflecting the impact of the divergent pattern of seasonal weight gain (Table 6.7.14). Analysis by yearly age classes was not conducted since the sample size was reduced to 40 as growth reference data used to compute BMI for age is only available from 24 months onwards. Annually, the overall estimated change in mean BMIZ was positive but statistically insignificant. This pattern prevailed for both male and females suggesting that the weight status for height of pre-school children aged 24-59 months improved slightly during the 1994/5 agricultural cycle (Table 6.7.15-6.7.16).

The results of the repeat measures ANCOVA examining the seasonal variation of the four repeated WAZ were less illustrative of its composite nature than expected. Rather the overall deviation in WAZ index closely mirrored the seasonal changes in the weight increment rather than being simultaneously modified by both height and weight velocities. The overall within-subject effect was statistically significant (p=0.016), the within-subject interaction between WAZ and age was also statistically significant (p=0.020) and the within-subject interaction between WAZ and gender was also just statistically significant (p=0.047) (Table 6.6.13).

The significant increase in WAZ observed over *pre-harvest* directly reflected the substantial weight gains during this period (F=9.901, p=0.003); similarly, the significant *post-harvest* decrease in WAZ epitomised the substantial decrease in weight velocity (F=7.440, p=0.009). The within-subject interaction between WAZ and gender was predominantly explained by the divergent patterns of male and female weight gain that occurred during the *pre-harvest* and *harvest* seasons. The variance in male and female weight gains generated a concurrent divergence in the change in WAZ. The gender difference of 0.243 observed during the *pre-harvest* period was not quite significant (F=3.913, p=0.053) whereas, the gender variance in the change in WAZ over the *harvest* period (0.374) was highly significant (F=8.884, p=0.004) (Table 6.6.14). Intra-annually there was statistically significant positive change between the initial and final WAZ (p=0.037) suggesting that weight gain for age had improved substantially for the pre-school population irrespective of the poor linear growth during the 1994/5 agricultural cycle (Table 6.6.15). The positive change in the estimated mean WAZ prevailed for both male and female pre-schoolers (Table 6.6.16).

6.7.2 Seasonal variation in nutritional status of primary school-aged population:

The results of the repeat measures ANOVA comparing the four rounds of HAZ indicated that there was significant within-subject difference (p=0.002). In addition, the within-subject interaction between HAZ and age across the four survey rounds was also highly significant (p<0.001) (Table 6.7.17), whereas the interaction between HAZ and gender were statistically insignificant suggesting that the pattern and deviation of HAZ for male and female children were similar. Overall, the relatively small mean incremental change in height over the *pre-harvest* period had a concurrent negative impact on the estimated mean HAZ which subsequently deteriorated (-0.052 Z-scores). In contrast, the increase in height velocity during *harvest* period had a simultaneous positive but statistically insignificant impact on HAZ. The subsequent decline in height increment during the *post-harvest* period had a concurrent negative impact on HAZ which was also statistically insignificant. The tests for the overall within-subject contrasts which compared the four HAZ serially using three pairwise comparisons were statistically insignificant, whereas the test for the within-subject interaction between HAZ and age indicated that there was a significant difference in the direction and extent of change in the pattern of linear growth over the *pre-harvest* period across the age-span of the primary school-aged population (F=5.210, p=0.026). Repeat measures ANOVA using yearly age classes as the between-subject factor and regressing age of the *pre-harvest* change in HAZ illuminated a significant inverse linear pattern, suggesting that the linear growth over the *pre-harvest* deteriorated -0.03 HAZ for every increase in age by one year within the primary school population (p=0.026) (Tables 6.7.25-6.7.33).

The seasonal pattern of the weight based indices BMIZ, WHZ and WAZ mirrored each other. All directly reflected the significant fluctuations in the incremental gains in body weight observed amongst the primary school population. The within-subject effect for BMIZ, WHZ and WAZ was highly significant for all three indices ($p<0.001$) (Table 6.7.17). The within-subject contrasts for BMIZ and WHZ suggested that the slight positive deviation in Z-score over the *harvest* period and subsequent larger decrease over the *post-harvest* period were statistically significant, whereas the three 4-monthly deviations in the WAZ were all statistically significant suggesting that WAZ was slightly more sensitive to seasonal oscillations in weight and less affected by the concurrent pattern of linear growth.

The pairwise comparisons between the initial and final HAZ, WHZ, BMIZ and WAZ indices provided conflicting results amongst the primary school-aged population. Over the 1994/5 agricultural season the estimated mean HAZ deteriorated significantly ($p<0.001$), indicating poor linear growth, whereas WHZ improved significantly ($p<0.001$) as did the other weight for height index BMIZ ($p=0.012$) (Table 6.7.19). Contrarily, the composite index WAZ improved only slightly simultaneously reflecting the negative annual deviation in HAZ and the positive change in the weight based indices. The results of the one-way ANCOVA used to compare the intra-annual change in each of the Z-scores by gender substantiated that the above pattern prevailed for both male and female primary school-aged children alike (Table 6.7.20), whereas, the annual pattern differed significantly by age for HAZ ($p<0.001$) and WAZ ($p<0.001$) within the primary school aged population (Table 6.7.20). Regressing age on the annual change in HAZ revealed a highly significant inverse linear relationship ($p=0.010$). The predicted change in HAZ increased by (-0.06 z-scores) with each year of age within the primary school population (Table 6.7.33). Similarly, there was a significant negative linear association between age and the annual change WAZ ($p=0.002$); the predicted decline in WAZ with each year of age (-0.065) mirrored the decrease in HAZ (Table 6.7.33).

6.7.3 Seasonal variation in nutritional status of the adolescent population: The results of the repeat measures ANCOVA examining overall and between-subject effect on the seasonal difference between the four successive HA z-scores suggested that there was a significant serial deterioration in HAZ ($p<0.001$). The decline in linear growth during the 1994/5 agricultural cycle was gradual amongst male adolescents whereas the deterioration in linear growth amongst their female counterparts was less pronounced. The within-subject effect of the repeat ANCOVA used to compare the *pre-harvest*, *harvest* and *post-harvest* HAZ changes were statistically insignificant substantiating the fairly constant decline in linear growth throughout the year (Table 6.7.21). In contrast, the change in BMIZ over the four survey rounds was significant reflecting the seasonal oscillations in weight gain observed throughout the year amongst adolescents (p=0.010). The large *pre-harvest* weight gains were reflected in an overall positive increase in BMIZ, whereas the relatively smaller *harvest* and minuscule *post-harvest* weight gains had a negative impact on the BMIZ. The repeat ANCOVA designed to compare the within-subject variation of the seasonal changes in BMIZ were all statistically insignificant indicating that the three 4-monthly changes in BMIZ were not significantly different from each other (Table 6.7.22).

The annual pairwise comparisons between the initial and final HAZ and BMIZ indices provided conflicting results amongst the adolescent population. Over the 1994/5 agricultural season the estimated mean HAZ deteriorated significantly (p=0.001), indicating poor linear growth whereas BMIZ improved slightly (Table 6.7.23). The results of the one-way ANCOVA used to compare the difference between the initial and final HAZ further substantiated that the above pattern prevailed for both male and female adolescents, whereas, the annual pattern differed significantly across the age-span of the adolescent population (p=0.006) (Table 6.7.24). The results of the one-way ANOVA used to compare the annual change in HAZ by yearly age classes was statistically insignificant. The disaggregation by yearly age classes was inconclusive; all age groups exhibited poor linear growth with the exception of 17 year olds. The deterioration in the linear growth rate was most pronounced amongst 10, 11 and 13 year olds. Regressing age on the annual incremental change of HAZ suggested that there was significant positive linear association with age with each year of life, the adolescent HA improving 0.0528 z-scores (p=0.002) (Table 6.7.35).

In contrast, the weight status for height improved slightly, the overall estimated mean change in BMIZ was positive but statistically insignificant (Table 6.7.23). One-way ANCOVA comparing the mean change in BMIZ by gender controlling for age highlighted that there was significant difference in the direction and extent of change in BMIZ within the adolescent age group by age (p=0.006) and gender (Table 6.7.24). There was a significant positive linear association between age and incremental change in BMIZ suggesting an improvement of 0.0813 BMIZ with each year of life (p=0.002). After controlling for age the gender disparity between male adolescents who on average lost and females who on average gained weight for height was not quite statistically significant (p=0.056) (Table 6.7.24). The regression equation suggested that on average adolescent girls gained 0.196 BMIZ more than boys of the same age (Table 6.7.35).

6.8 Association between initial nutritional status and seasonal growth velocities

Analyses were carried out to examine if the seasonal variation in weight and height increments depended on the child's initial growth status. The 4-monthly growth increments representing *pre-harvest, harvest* and *post-harvest* weight and height were regressed on initial WHZ, HAZ, BMIZ. This analysis was repeated for each of the three discrete periods of childhood. In each case age was included as covariant to correct for the higher growth velocities during infancy within the pre-school age group and puberty within adolescence.

6.8.1 The relationship between initial weight and height status and prospective weight gain amongst pre-school population: After controlling for the linear and higher order effects of age the association between initial WHZ status and weight gain during the *pre-harvest, harvest* or *post-harvest* seasons and annually were statistically insignificant for the pre-school population (Table 6.8.4). A repeat measures ANCOVA was used to compare the seasonal pattern and incremental gain in weight of children diagnosed as wasted or of adequate weight for height using a dichotomous classification of weight status as the between-subject effect (Wasted:<-1.5 WHZ or

Adequately nourished WHZ $\geq$-1.5)[5] was also statistically insignificant. Both the seasonal pattern and incremental weight gains of thin and adequately nourished children were comparable. Thinner children gained slightly less weight than their adequately nourished counterparts during the *pre-harvest* period and gained slightly more during the following *harvest* and *post-harvest* periods. Despite the larger incremental gains in weight after *harvest* their annual weight increment was slightly lower than their adequately nourished counterparts suggesting that thinner children experienced continual growth retardation (Table 6.8.6).

Similarly, stunted (<-2 HAZ) pre-school children gained slightly less weight during the *pre-harvest* and *harvest* periods and slight more during the *post-harvest* period compared to their taller counterparts (Table 6.8.4). Over the year stunted (<2 HAZ) pre-school children gained slightly less weight than those initially diagnosed with adequate height for age suggesting shorter children also continued to exhibit lower weight gains compared to their taller counterparts (Table 6.8.6).

6.8.2 The relationship between initial weight and height status and prospective height gains amongst pre-school population: Pre-school children classified as thin (<-1.5 WHZ) at the outset of the study, consistently exhibited lower incremental gains in height than their adequately nourished ($\geq$-1.5 WHZ) counterparts in all three seasons, suggesting thinner pre-school children experienced continual linear growth retardation. Contrarily, regressing the *pre-harvest* height gains on initial HAZ status after controlling for age suggested that shorter children exhibited significantly larger gains in height (p=0.031) (Table 6.8.1). A repeat measures ANCOVA was used to compare the seasonal pattern and incremental gain in height of children diagnosed as stunted or of adequate height for age using a dichotomous classification of height status as the between-subject effect (Stunted:<-2 HAZ). The within-subject effect of the seasonal height increments was highly significant (p<0.001), as was the within-subject interaction between seasonal height gains and covariant age (p<0.001), and the within-subject interaction between incremental height velocity and initial height

[5] *The WHZ cut-off point was increased to -1.5 to reflect the WHZ distribution.*

status (p=0.035) (Table 6.8.5). The within-subject contrasts used to compare the seasonal height increments serially indicated that there was significant heterogeneity between the *pre-harvest* and *harvest* height velocities overall (F=17.174, p<0.001), by age (F=15.409, p<0.001) and by initial height status (F=4.870, p=0.032). After controlling for age, the estimated mean *pre-harvest* incremental height velocity of stunted children was (1.04 cm) greater than their counterparts, indicating that shorter children experienced greater linear growth during the *pre-harvest* period. Contrarily, the reverse situation was observed during the *harvest* and *post-harvest* periods, after controlling for age stunted children presented lower incremental height gains. In both, the *pre-harvest* (-0.78 cm) and *post-harvest* (-0.11cm) seasons the difference in height gains between stunted and non-stunted pre-school children were both statistically insignificantly. After controlling for the curvilinear effects of age stunted pre-school children grew on average 0.32 cm more over the 1994/5 agricultural cycle than those initially diagnosed as non-stunted. The difference in the annual height increment between stunted children and their taller counterparts was statistically insignificant. In comparison, thinner children exhibited successively lower incremental gains in height in all three seasons, accumulating in an annual incremental height difference of 0.89 cm. The seasonal and annual height velocities difference between children initially diagnosed as thin (<-1.5 WHZ) and those classified with adequate weight for height were all statistically insignificant (Table 6.8.5).

6.8.3 The relationship between initial weight and height status and prospective weight gains amongst primary school-aged population: Regressing the *pre-harvest* weight gain on initial WHZ after the inclusion of the age illuminated a significant inverse association; with each WHZ. The primary school children gained -0.224 kg less weight with each initial WHZ z-score (p=0.045). Indicating that within the primary school-aged population thinner children gained significantly more weight over their *pre-harvest* period. Conversely, a positive linear relationship was observed between initial height status and *pre-harvest* weight gains, with each HAZ children gained 0.239 kg more weight (p=0.012) hence shorter primary school-aged children gained significantly less weight (Table 6.8.2). The results of repeat measures

ANCOVA used to compare the seasonal pattern and incremental gain in weight of children diagnosed as thin or of adequate weight for height indicated that there was no additional effect of initial WHZ status (Table 6.8.7).

The seasonal pattern of weight gain of thin primary school-aged children mirrored that of their adequately nourished counterparts, exhibiting their highest incremental weight gains in the *pre-harvest* period and their lowest in the *post-harvest* period. On average primary school-aged children initially diagnosed as thin at the start of the study gained 0.393 kg more weight over the 1994/5 agricultural season compared to their adequately nourished counterparts. The intra-annual difference in weight gain by initial nutritional status was statistically insignificant (Table 6.8.9). Contrarily, the within-subject interaction between initial height for age status and the seasonal pattern and incremental gain in weight was highly significant (p=0.016) (Table 6.8.7). The within-subject contrasts indicated that there was significant difference between the estimated mean *pre-harvest* and *harvest* weight changes (F=4.803, p=0.032). A different seasonal pattern emerged between stunted primary school-aged children and their taller counterparts. Children initially diagnosed with adequate height for age exhibited their highest incremental gains in weight during the *pre-harvest* period whereas stunted children exhibited their highest weight gain during *harvest* period. During the *post-harvest* period stunted children exhibited a weight loss (-0.441 kg); in contrast their taller counterparts continued to demonstrate a positive increase in weight. Serially, the difference between estimated mean *harvest* and *post-harvest* weight changes of the stunted and non-stunted primary school-aged children was statistically significant (F=7.143, p=0.009). After controlling for age the intra-annual weight gain of non-stunted primary school children was in excess of half a kilogram (0.640kg) more than their stunted counterparts, the difference in annual weight gain was statistically insignificant (Table 6.8.9).

6.8.4 The relationship between initial weight and height status and prospective height gains amongst primary school-aged population: The within and between-subject effect of initial weight and height status on the prospective incremental height gains amongst primary school-aged population were all statistically insignificant (Table 6.8.8). These results suggest that the pattern and absolute incremental height velocities observed in the *pre-harvest*, *harvest* and *post-harvest* of malnourished (thin or stunted children) were comparable to their adequately nourished counterparts. Both thin and stunted children exhibited slightly lower annual height velocities (Table 6.8.9).

6.8.5 The relationship between initial weight and height status and prospective weight gains amongst adolescent population: There was no significant relationship between initial BMIZ and HAZ after controlling for the effect of age on the prospective *pre-harvest* and *harvest* weight gains amongst adolescents. In contrast, during the *post-harvest* season thinner adolescents gained significantly more weight than stunted adolescents (Table 6.8.10). After controlling for age, thin adolescents exhibited slightly higher annual weight gains compared to the adequately nourished counterparts whereas stunted adolescents gained less weight than their taller counterparts (Table 6.8.12).

6.8.6 The relationship between initial weight and height status and prospective height gains amongst adolescent population: There was no significant relationship between initial BMIZ and HAZ after controlling for the linear effect of age on the prospective *pre-harvest* and *harvest* height gains amongst adolescents. After controlling for the significant linear effect of age ($p<0.001$) the inverse relationship between the *post-harvest* height gain and initial weight status predicted that for each BMIZ the height gain was 0.590 cm less ($p<0.001$) (Table 6.8.3). Similarly, the inverse association between *post-harvest* height gain and initial height status predicted that for each HAZ the incremental gain in height amongst adolescents was 0.263 cm lower ($p=0.027$) (Table 6.8.3). The 15% of adolescents diagnosed as thin at the start of the study gained 1.5 times incremental height gain of the adequately nourished, the 2.14 cm difference in the annual incremental gain in height was highly significant ($p<0.001$) (Table 6.8.12). Likewise, stunted adolescents demonstrated a slightly larger annual height velocity which was statistically insignificant (Table 6.8.12).

6.9 Seasonal variation in the prevalence of malnutrition

The above analysis presented change in mean HAZ, BMIZ, WHZ and WAZ within and between age groups. This analysis gives limited insight into the seasonal variation of malnutrition. Using a dichotomous classification to diagnose malnutrition the seasonal prevalence rates of stunting (<-2 HAZ), thinness (<-2 BMIZ), wasting (<-2 WHZ) and underweight (<-WAZ) were compared. McNemar's test of symmetry was used to measure whether, in repeat rounds of measurement, the change in prevalence of malnourishment was significant. This analysis was carried out for the child population as a whole and by discrete period of childhood for each anthropometric index.

6.9.1 Seasonal variation in the prevalence of stunting: The prevalence rates of stunting (<-2 HAZ) for the whole child population for Nov-94, Mar-95, Jul-95 and Nov-95 were 19.7%, 23.9%, 22.9% and 21.3%, respectively (Table 6.9.1). These prevalence rates of stunting suggest that approximately one in five children were short for their age compared to the NCHS reference median, a situation classified as medium nutritional risk. As expected with a long term indicator, the seasonal variation in the incidence of stunting was minimal ranging between 1-4.2%. The largest oscillation in the incidence of stunting occurred over the *pre-harvest* period. The 4.2% increase resulted in the incidence of stunting peaking at the end of the hungry season to 23.9% (Table 6.9.1). Over the *harvest* and *post-harvest* periods the incidence of stunting fluctuated only slightly, these periods exhibited successive declines of 1.0% and 1.6%, respectively. Irrespective of the sequential decline after harvest the year on year comparisons suggest that there was a slight inconsequential increase in prevalence of stunting amongst the whole child sample of 1.6% (Table 6.9.9).

The seasonal and annual variation in the prevalence rates of stunting over the whole study period were statistically insignificant for the whole child sample, and within the pre-school and adolescent age groups (Tables 6.9.1, 6.9.9, 6.9.11 and 6.9.19). Rather, the oscillation in *pre-harvest* prevalence rates in stunting were generally associated with males and primary school-aged children (Table 6.9.2 and 6.9.15). The increase in the prevalence rate of stunting amongst primary school-aged children over the *pre-harvest* period were statistically significant nearly doubling from 9.6% to 17.8% (p=0.031) (Table 6.9.15). Similarly, the prevalence of stunting also increased significantly for male children during the *pre-harvest* period from 17.3% to 25.9% (p=0.016) (Table 6.9.2). In comparison, the seasonal variation in stunting was minimal and statistically insignificant amongst females (Table 6.9.3). It is evident from examining the distribution of child population by HAZ category that the *pre-harvest* seasonal changes in the prevalence of stunting was evidently caused by children moving from the mild to the moderately stunted category rather being caused by a general shift in whole distribution.

6.9.2 Seasonal variation in the prevalence of thinness: In comparison to stunting there was a statistically significant seasonal variation in the incidence of thinness (<-2 BMIZ), the pattern varying by gender and age group. For the whole child sample the prevalence of thinness decreased 4.0% from 15.0% to 11.0% over the *pre-harvest* period. Over the *harvest* period the incidence of thinness continued to decline, the subsequent 4.1% decrease to 6.9% was statistically significant (p=0.039) for the whole child population. Over the *post-harvest* period there was a slight increase in the prevalence of thinness to 10.4%. Intra-annually the risk ratio of thinness decreased by two-thirds (0.66) from 15.0% to 10.4%, the decline in the incidence of thinness was statistically insignificant. The seasonal pattern of thinness varied by gender. The incidence of thinness decreased significantly for males during the *pre-harvest* period from 20.5 to 12.8% (p=0.031), whereas, the prevalence of female thinness decreased substantially during the *harvest* period but the decline of 5.3% was not quite significant.

6.9.3 Seasonal variation in the prevalence of wasting: The prevalence of wasting (<-2 WHZ) was low throughout the year for the whole child population 0-9.99 years ranging between 0.8-6.3%. The seasonal fluctuations in the prevalence of wasting peaked over the *pre-harvest* period and subsequently declined over the *harvest* and *post-harvest* period; this pattern prevailed for both the pre-school and primary school population. Over the *pre-harvest* period the prevalence of wasting peaked increasing 1.5% from 4.8% to 6.3%. Over the *harvest* period there was a substantial and statistically significant decrease in the prevalence of wasting from 5.5% to 0.8% (p=0.039). Over the *post-harvest* period the incidence of wasting subsequently increased slightly to 1.6%. The annual decline in the prevalence of wasting of 3.1% was statistically insignificant. The oscillation of pre-school wasting ranged between (1.8%-10.9%), the fluctuation was more severe than that observed amongst primary school children which ranged between (0.0-2.9%).

6.9.4 Seasonal variation in the prevalence of underweight: The overall prevalence rate of underweight (<-2 WAZ) amongst children aged <10 years ranged between 19.5% to 10.2%. One in five children aged <10 years was diagnosed underweight in November; this was substantially reduced to one in ten in July. Seasonal changes in the prevalence of underweight and the overall annual decrease were all statistically insignificant for both the pre-school and primary school populations.

6.10 Summary

1. The study design created two different longitudinal data-sets. Longitudinal sample 1 had four repeat measures and longitudinal sample 2 had three repeat measures. The demographic profile and anthropometric measures from each longitudinal sample were compared with each other and subjects who had only one or two measures to check the representativeness of the longitudinal samples by age group, gender and season.
2. Significant age differences were observed between the two longitudinal samples and the cross-sectional samples for both male and female adults. After controlling for age the difference between the anthropometric measures and the prevalence rate of malnutrition were statistically insignificantly. Similarly, significant age differences were observed between the two longitudinal samples and cross-sectional child samples which were partially attributed to study design. After

controlling for age the difference in the anthropometric measures and indicators were also statistically insignificant.

3. The repeated measures analysis elucidated a sequential downward spiralling pattern of nutritional status during the drought prone 1994/5 agricultural cycle for both children and adults. Weight gains were significant and peaked during the *pre-harvest* period for both adults and children. This was followed by a slight decline in the incremental weight velocity amongst children and a slight loss in weight amongst adults during the *harvest* period. Over the *post-harvest* period, weight increments ebbed to minuscule gains amongst children and to a significant weight loss amongst adults.
4. The seasonal fluctuations in adult body weight were modest. The estimated mean absolute weight change during each season ranged between -1.37 to 2.37 kg; these were equivalent to relative weight changes of -2.4 to 4.0%. Similarly, mean adult annual weight change was minimally, positive 0.5 ± 2.4 kg and statistically insignificant approximating to 1.0 ± 4.3% relative change in body weight. The distribution, extent and severity of seasonal weight changes varied within the adult population.
5. Female adults and children faired better nutritionally than their male counterparts over the 1994/5 drought. Adult women gained a significant amount of weight whereas men exhibited an inconsequential weight loss. On average female children gained more weight than their male counterparts in each discrete period of childhood. Although, the gender difference was statistically insignificant by age group when the positive female weight gains observed in each discrete period of childhood were aggregated across the whole child population, girls gained significantly more absolute weight (kg) and relative (%) weight compared to their male counterparts after controlling for age.
6. The annual decline in the prevalence of CED observed amongst adult men (4.3%) and women (4.0%) were similar. However, the proportional decline in CED was not comparable due to the significant gender disparity in the distribution of nutritional status. During the year women were 4.7-17.3 times less likely to be diagnosed with CED compared to their male counterparts. The prevalence of CED

amongst men were 3.3-10.4 times higher than that observed amongst women. Subsequently, the 4% annual decline in the incidence of CED actually reduced the female prevalence rate of CED by a third and the male by a tenth.

7. The pattern and extent of seasonality varied significantly by age group for both the adult and child population. Amongst the adult population the elderly exhibited the highest degree of nutritional risk and the largest oscillation in nutritional status. Amongst the child population if the prevalence rates of stunting and thinness are considered concurrently, adolescents had consistently higher levels compared to their younger counterparts and their linear growth deteriorated the most over the year.
8. The peaks and troughs of weight and height gains for the pre-school population differed from the primary school-aged and adolescent populations who imitated each other. The different seasonal pattern was largely attributed to the additive effect of post-natal growth spurt. The highest weight increments were observed in *pre-harvest* period for primary school and adolescents and *harvest* period for pre-school children. In each case the weight increments exceeded the 4-monthly weight velocity derived from the NCHS WA median. The lowest weight gains were observed in *post-harvest* period for all three age groups; all weight increments in this period were significantly lower than the 4-monthly increments derived from the NHCS WA median.
9. Height was less affected by seasons than weight for all three discrete periods of childhood. In each season the observed estimated mean incremental gain in height was lower than those derived from the NCHS median for a similar demographic profile.
10. The results of the repeated measures analyses indicated that children exhibited statistically significant ponderal and linear growth. However, the respective weight and height increments were inadequate to maintain the growth trajectory observed at the start of the study. Despite this significant inter-annual gains in BMIZ, WHZ and WAZ indicated a steady increase in weight gain and concurrent decrease in the degree thinness, wasting and underweight. There was simultaneous decline in HAZ

for all age groups suggesting a deceleration in linear growth which was statistically significant for the primary school-aged and adolescent populations.

11. The amplitude of the oscillations in weight and height velocities varied with age. Children aged 5-9.99 years in middle childhood and the latent stage of growth exhibited more seasonality. The peaks and troughs of the incremental gains in weight and height amongst primary school-aged children were more pronounced compared to pre-school and adolescents.
12. As expected the annual absolute and relative weight and height gains of pre-school and adolescents were higher than primary school-aged children. During periods of increased growth such post-natal and puberty, the peaks and troughs were more pronounced.
13. There was a distinct lagged relationship between the gain in height which succeeded the gain in weight. Generally, weight gains peaked in the *pre-harvest* period whereas height increments were more prominent over the subsequent *harvest* period.
14. There was distinct inverse relationship between initial nutritional status and prospective seasonal and annual weight change amongst both adults and children. Over the 1994/5 drought thinner adults and children were the most protected. Within the adult population a distinct linear trend emerged with the CED gaining weight and the over-nourished exhibiting the highest weight loss. Similarly, thin children gained more absolute weight than their adequately nourished counterparts in all three age groups. Stunted pre-school children and adolescents exhibited the largest incremental gains in height; the converse was observed for primary school-aged children. This result suggests that catch-up in linear growth was most prominent during post-natal and pubertal phases of growth.
15. The seasonal changes in adult and child (MUAC) were highly positively correlated with weight in each season and annually. However, the seasonal changes in MUAC were less pronounced than weight changes and seemingly lagged for both adults and children.
16. Adult and child malnutrition rates were synchronised to some extent. Chronic energy deficiency (CED) and child thinness (<-2 BMIZ) and underweight (<-2

WAZ) all peaked in November. The major discrepancies were observed in March at the end of *pre-harvest* season with the coexistence of maximum rates of child wasting (<-2 WHZ) and stunting (<-2 HAZ) and lowest rates of adult CED. Contrarily, children exhibited the lowest rates of wasting, thinness and underweight in July at the end of the *harvest* period.

17. The higher prevalence rates of malnutrition were predicted to occur in *pre-harvest* or *hungry season* (Nov-94 to Mar-95) but conversely transpired to be the period exhibiting significant decrease in CED amongst adults and the largest weight gains amongst children. The unseasonal pattern of nutritional status is partially attributed to the prevailing drought and consequential poor yields and subsequent reliance on food relief which was promptly distributed.

Tables Chapter 6
Tables section 6.3

Longitudinal sample 1: Adult weight by gender and survey round							
Survey	Total Pop. n=73	Male n=23	Female n=51	Main effect	df	F	*p*
round	Mean SD	Mean SD	Mean SD				
Nov-94	58.9 ± 13.8	57.8 ± 13.1	59.9 ± 12.3	Weight	2.805	4.144	0.008
Mar-95	61.2 ± 14.2	60.0 ± 13.4	62.5 ± 12.5	Weight * age	2.805	3.383	0.022
Jul-95	60.9 ± 13.7	59.5 ± 13.0	62.2 ± 12.2	Weight * gender	2.805	1.878	n.s.
Nov-95	59.4 ± 13.3	58.2 ± 12.6	60.7 ± 11.8	Weight*gender*age	2.805	2.740	0.048

Table 6.3.1: *Repeat measures ANCOVA within-subject effect of gender after controlling for age and age*gender interactions on seasonal weight measures for longitudinal sample 1*

Longitudinal sample 1: Adult BMI by gender and survey round							
Survey	Total Pop. n=73	Male n=23	Female n=51	Main effect	df	F	*p*
round	Mean SD	Mean SD	Mean SD				
Nov-94	21.9 ± 4.9	20.1 ± 4.7	23.8 ± 4.4	BMI	2.871	3.612	0.016
Mar-95	22.8 ± 5.1	20.8 ± 4.8	24.8 ± 4.5	BMI * age	2.871	3.072	0.031
Jul-95	22.7 ± 4.9	20.7 ± 4.7	24.7 ± 4.4	BMI * gender	2.871	1.620	n.s.
Nov-95	22.2 ± 4.8	20.2 ± 4.5	24.1 ± 4.2	BMI*gender*age	2.871	2.449	n.s.

Table 6.3.2: *Repeat measures ANCOVA within-subject effects of gender after controlling for age and age*gender interactions on seasonal BMI measures for longitudinal sample 1*

Longitudinal sample 1: Adult MUAC by gender and survey round							
Survey	Total Pop. n=73	Male n=23	Female n=51	Main effect	df	F	*p*
round	Mean SD	Mean SD	Mean SD				
Nov-94	28.1 ± 4.9	26.9 ± 4.7	29.3 ± 4.0	MUAC	2.803	1.562	n.s
Mar-95	28.4 ± 4.7	27.2 ± 4.6	29.6 ± 3.9	MUAC * age	2.803	1.144	n.s.
Jul-95	28.0 ± 4.5	26.7 ± 4.4	29.4 ± 3.7	MUAC * gender	2.803	1.549	n.s.
Nov-95	27.6 ± 4.6	26.2 ± 4.5	29.1 ± 3.8	MUAC*gender*age	2.803	1.818	n.s.

Table 6.3.3: *Repeat measures ANCOVA within-subject effects of gender and age*gender interactions after controlling for age on seasonal MUAC measures for longitudinal sample 1*

Longitudinal sample 1: Adult delta weight by gender and survey round										
Survey round	**Total Pop. n=73**		**Male n=23**		**Female n=50**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94 to Mar-95	2.37	2.2	2.24	2.0	2.50	1.9	Delta weight	2	7.584	0.001
Mar-95 to Jul-95	-0.38	2.6	-0.52	2.4	-0.25	2.3	Delta weight * age	2	6.447	0.002
Jul-95 to Nov-95	-1.37	2.1	-1.23	2.0	-1.48	1.9	Delta weight * gender	2	0.352	n.s.
							Delta weight * age * gender	2	0.340	n.s.

Table 6.3.4: *Repeat measures ANCOVA within-subject effects of gender and age*gender interactions after controlling for age on seasonal weight measures for longitudinal sample 1*

Longitudinal sample 1: Adult delta BMI by gender and survey round										
Survey round	**Total Pop. n=73**		**Male n=23**		**Female n=50**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94 to Mar-95	0.89	0.8	0.77	0.8	1.0	0.7	Delta BMI	2	6.528	0.002
Mar-95 to Jul-95	-0.13	1.0	-0.16	0.9	-0.09	0.9	Delta BMI * age	2	5.805	0.004
Jul-95 to Nov-95	-0.52	0.8	-0.44	0.8	-0.60	0.7	Delta BMI * gender	2	0.141	n.s.
							Delta BMI * age * gender	2	0.141	n.s.

Table 6.3.5: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal body mass index (BMI) measures for longitudinal sample 1*

Longitudinal sample 1: Adult delta MUAC by gender and survey round										
Survey round	**Total Pop. n=67**		**Male n=20**		**Female n=47**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94 to Mar-95	0.34	1.3	0.33	1.2	0.35	1.1	Delta MUAC	1.98	2.842	n.s.
Mar-95 to Jul-95	-0.36	1.3	-0.54	1.3	-0.18	1.1	Delta MUAC * age	1.98	2.667	n.s.
Jul-95 to Nov-95	-0.41	1.1	-0.46	1.0	-0.40	0.9	Delta MUAC * gender	1.98	3.863	0.024
							Delta MUAC * age * gender	1.98	0.141	0.014

Table 6.3.6: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal MUAC measures for longitudinal sample 1*

Longitudinal sample 1: Adult relative (%) change in weight by gender and survey round										
Survey round	**Total Pop. n=73**		**Male n=23**		**Female n=50**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94 to Mar-95	4.10	3.9	3.94	3.7	4.28	3.4	Relative weight change	2	6.421	0.002
Mar-95 to Jul-95	-0.38	4.6	-0.54	4.3	-0.22	4.0	Relative weight change * age	2	5.526	0.005
Jul-95 to Nov-95	-2.15	3.6	-1.98	3.5	-2.32	3.2	Relative weight change * gender	2	0.157	n.s.
							Relative weight change * age * gender	2	0.108	n.s.

Table 6.3.7: *Repeat measures ANCOVA within-subject effects of gender and age*gender interactions after controlling for age on seasonal relative (%) weight changes for longitudinal sample 1*

Longitudinal sample 1: Adult relative (%) change in MUAC by gender and survey round										
Survey round	**Total Pop. n=67**		**Male n=20**		**Female n=47**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94 to Mar-95	1.54	5.5	1.42	5.2	1.67	4.5	Relative MUAC change	2	2.779	n.s.
Mar-95 to Jul-95	-1.30	5.5	-1.84	5.2	-0.76	4.5	Relative MUAC change * age	2	2.628	n.s.
Jul-95 to Nov-95	-1.51	3.8	-1.82	3.6	-1.20	3.2	Relative MUAC change * gender	2	2.952	n.s.
							Relative MUAC change * age * gender	2	3.628	0.036

Table 6.3.8: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal relative (%) MUAC changes for longitudinal sample 1*

Longitudinal sample 1: Adult inter-annual weight change by gender and survey round										
Survey	Total Pop.n=73		Male n=23		Female n=50		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94	58.6	13.0	57.8	12.1	59.4	12.1	Weight	1	1.081	n.s.
Nov-95	58.9	12.6	57.7	11.7	60.1	11.7	Weight*gender	1	1.752	n.s.

Table 6.3.9: *Repeat measures ANOVA within-subject effect of gender on inter-annual weight changes for longitudinal sample 1*

Longitudinal sample 1: Adult absolute inter-annual weight change by gender and survey round										
Survey	Total Pop. n=73		Male n=23		Female n=50		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94	58.9	13.8	57.8	13.1	59.9	12.3	Weight	1	4.523	0.037
Nov-95	59.5	13.3	58.2	12.6	60.7	11.8	Weight*age	1	2.950	n.s.
							Weight*gender	1	4.903	0.030
							Weight*age*gender	1	7.121	0.009

Table 6.3.10: *Repeat measures ANCOVA within-subject effect of gender on inter-annual weight changes for longitudinal sample 1*

Longitudinal sample 1: Adult absolute inter-annual weight change by gender and survey round										
Survey	Total Pop. n=73		Male n=23		Female n=50		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94 to Nov-95	0.32	2.6	-0.087	2.4	0.724	2.4	Gender	2	1.752	n.s.
Longitudinal sample 1: Adult relative(%) inter-annual weight change by gender and survey round										
Nov-94 to Nov-95	0.75	4.6	0.05	4.3	1.45	4.3	Gender	2	1.647	n.s.

Table 6.3.11: *One-way ANOVA within-subject effect of gender on seasonal absolute and relative (%) weight changes for longitudinal sample 1*

Longitudinal sample 2: Adult weight by gender and survey round										
Survey round	**Total Pop. n=318**		**Males n=110**		**Females n=208**					
Age group	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Mar-95										
18-21.99	57.5	10.7	59.3	10.7	55.6	10.7				
22-59.99	60.6	12.1	59.6	10.7	61.6	10.7				
≥60	56.7	10.7	58.7	10.7	54.7	10.7				
All	58.3	14.5	59.2	12.0	57.3	16.6				
Jul-95							Weight	1.88	30.922	<0.001
18-21.99	59.0	10.6	60.4	10.5	57.5	10.7	Weight*Age grp.	3.75	5.845	<0.001
22-59.99	60.4	12.0	59.6	10.5	61.3	10.5	Weight*Sex	1.88	0.477	n.s.
≥60	56.9	10.5	58.7	10.5	55.2	10.5	Weight*Age grp*Sex	3.75	0.821	n.s.
All	58.8	14.3	59.6	11.3	58.0	16.4				
Nov-95										
18-21.99	57.9	10.4	59.8	10.4	56.0	10.4				
22-59.99	59.1	11.8	58.1	10.4	60.1	10.4				
≥60	55.3	10.4	57.2	10.4	53.4	10.4				
All	57.4	14.1	58.4	11.7	56.5	16.1				

Table 6.3.13*: Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal weight (kg) measures for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult BMI by gender and survey round										
Survey round	Total Pop. n=318		Males n=110		Females n=208					
Age group	Mean	SD	Mean	SD	Mean	SD	Main effect	df	F	*p*
Mar-95										
18-21.99	21.1	4.0	20.2	4.0	21.9	4.0				
22-59.99	22.4	4.5	20.6	4.0	24.3	4.0				
≥60	21.2	4.0	20.4	4.0	22.1	4.0				
All	21.6	5.4	20.4	4.5	22.8	6.2				
Jul-95							BMI	1.899	29.020	<0.001
18-21.99	21.7	3.9	20.6	3.9	22.7	3.9	BMI*Age grp.	3.798	5.913	<0.001
22-59.99	22.4	4.4	20.6	3.9	24.2	3.9	BMI*Sex	1.899	1.026	n.s.
≥60	21.4	3.9	20.4	3.9	22.3	3.9	BMI*Age grp*Sex	3.798	0.931	n.s.
All	21.8	5.3	20.5	4.4	23.1	6.1				
Nov-95										
18-21.99	21.3	3.9	20.4	3.9	22.1	3.9				
22-59.99	21.9	4.4	20.0	3.9	23.7	3.9				
≥60	20.7	3.9	19.9	3.9	21.6	3.9				
All	21.3	5.3	20.1	4.4	22.5	6.0				

Table 6.3.14: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal BMI measures for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult MUAC by gender and survey round										
Survey round	**Total Pop. n=318**		**Males n=110**		**Females n=208**					
Age group	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Mar-95										
18-21.99	26.0	3.3	26.0	3.3	26.0	3.3				
22-59.99	27.7	3.8	26.2	3.3	29.3	3.3				
≥60	26.8	3.3	25.7	3.3	27.8	3.3				
All	26.8	4.6	25.9	3.8	27.7	5.4				
Jul-95							MUAC	3.947	6.302	0.002
18-21.99	26.5	3.3	26.1	3.2	26.9	3.2	MUAC*Age grp.	4.251	6.787	<0.001
22-59.99	27.8	3.7	26.4	3.2	29.2	3.2	MUAC*Sex	1.910	0.338	n.s.
≥60	26.5	3.2	25.5	3.2	27.5	3.2	MUAC*Age grp*Sex	3.820	1.355	n.s.
All	26.9	4.6	26.0	3.7	27.8	5.3				
Nov-95										
18-21.99	26.5	3.3	26.3	3.2	26.8	3.2				
22-59.99	27.3	3.7	26.0	3.2	28.7	3.2				
≥60	25.9	3.2	25.0	3.2	26.8	3.2				
All	26.6	4.6	25.8	3.7	27.4	5.3				

Table 6.3.15: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal MUAC (cm) measures for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult delta weight by gender and survey round										
	Total Pop. n=318		Male n=110		Female n=208		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Mar-95 to Jul-95										
18-21.99	1.507	2.2	1.100	2.2	1.914	2.2				
22-59.99	-0.183	2.5	-0.02	2.2	-0.346	2.2	Delta weight	1	55.679	<0.001
≥60	0.272	2.2	0.041	2.2	0.503	2.2	Delta weight * age group	2	3.180	0.043
All	0.532	2.9	0.374	2.4	0.690	3.4	Delta weight * gender	1	1.301	n.s.
Jul-95 to Nov-95							Delta weight * age group * gender	2	2.181	n.s.
18-21.99	-1.091	2.0	-0.653	2.0	-1.529	2.0				
22-59.99	-1.324	2.3	-1.484	2.0	-1.163	2.0				
≥60	-1.619	2.0	-1.511	2.0	-1.726	2.0				
All	-1.344	2.7	-1.216	2.3	-1.473	3.1				

Table 6.3.16: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal weight (kg) change for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult relative percentage weight change by gender and survey round										
	Total Pop. n=318		Male n=110		Female n=208		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Mar-95 to Jul-95										
18-21.99	2.888	3.7	2.123	3.7	3.654	3.7				
22-59.99	-0.225	4.2	0.025	3.7	-0.457	3.7	Relative weight	1	59.992	<0.001
≥60	0.514	3.7	0.056	3.7	0.971	3.7	Relative weight * age group	2	3.918	0.021
All	1.059	5.0	0.735	4.2	1.383	5.8	Relative weight * gender	1	2.120	n.s.
Jul-95 to Nov-95							Relative weight * age group * gender	2	2.648	n.s.
18-21.99	-1.801	3.4	-0.927	3.4	-2.675	3.4				
22-59.99	-2.137	3.8	-2.403	3.4	-1.871	3.4				
≥60	-2.735	3.4	-2.464	3.4	-3.007	3.4				
All	-2.225	4.6	-1.931	3.8	-2.518	5.2				

Table 6.3.17: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal relative weight (%) change for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult delta BMI by gender and survey round										
	Total Pop. n=318		Male n=110		Female n=208		Main effect	df	F	p
	Mean	SD	Mean	SD	Mean	SD				
Mar-95 to Jul-95										
18-21.99	0.583	0.8	0.386	0.8	0.779	0.8				
22-59.99	-0.073	0.9	-0.011	0.8	-0.134	0.8	Delta BMI	1	52.266	<0.001
≥60	0.104	0.9	0.009	0.8	0.199	0.8	Delta BMI * age group	2	3.274	0.039
All	0.205	1.1	0.128	0.9	0.281	1.3	Delta BMI * gender	1	2.786	n.s.
Jul-95 to Nov-95							Delta BMI * age group * gender	2	2.465	n.s.
18-21.99	-0.408	0.8	-0.216	0.8	-0.600	0.8				
22-59.99	-0.487	0.9	-0.514	0.8	-0.460	0.8				
≥60	-0.597	0.8	-0.506	0.8	-0.689	0.8				
All	-0.497	1.1	-0.412	0.9	-0.583	1.2				

Table 6.3.18: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal change in Body Mass Index (BMI) for longitudinal sample 2 (n=318)*

Longitudinal sample 2: Adult delta MUAC by gender and survey round										
	Total Pop. n=318		Male n=110		Female n=208		Main effect	df	F	p
	Mean	SD	Mean	SD	Mean	SD				
Mar-95 to Jul-95										
18-21.99	0.479	1.0	0.138	1.0	0.820	1.0				
22-59.99	0.044	1.2	0.223	1.0	-0.136	1.0	Delta MUAC	1	9.393	0.002
≥60	-0.227	1.0	-0.197	1.0	-0.256	1.0	Delta MUAC * age group	2	0.166	n.s.
All	0.099	0.8	0.055	1.2	0.143	1.6	Delta MUAC * gender	1	0.786	n.s.
Jul-95 to Nov-95							Delta MUAC * age group * gender	2	1.495	n.s.
18-21.99	0.060	1.0	0.169	1.0	-0.050	1.0				
22-59.99	-0.450	1.2	-0.419	1.0	0.482	1.0				
≥60	-0.583	1.0	0.488	1.0	-0.678	1.0				
All	0.325	1.1	-0.246	1.2	-0.403	1.7				

Table 6.3.19: *Repeat measures ANOVA comparing within-subject effects of age group and gender on seasonal change in MUAC (cm) for longitudinal sample 2 (n=318)*

Sample 1: Seasonal distribution of relative weight losses and gains by gender													
		Pre-harvest [a]			Harvest [b]			Post-harvest [c]			Inter-annually [d]		
Weight change category	%	Total Pop.	M	F	Total Pop.	M	F	Total Pop.	M	F	Total Pop.	M	F
Severe loss	≥-7.5	0.0	0.0	0.0	2.7	0.0	4.0	5.5	4.3	6.0	4.1	8.7	2.0
Moderate loss	-5.0 to -7.49	0.0	0.0	0.0	11.0	21.7	6.0	13.7	26.1	8.0	5.5	4.3	6.0
Mild loss	-0.1 to -4.9	8.2	21.7	2.0	41.1	26.1	48.0	60.3	52.2	64.0	30.1	34.8	28.0
Mild gain	0.1-4.9	56.2	47.8	60.0	38.4	43.5	36.0	19.2	17.4	20.0	45.2	43.5	46.0
Moderate gain	5.0-7.49	20.5	13.0	24.0	4.1	4.3	4.0	1.4	0.0	2.0	6.8	4.3	8.0
Large gain	≥7.5	15.1	17.4	14.0	2.7	4.3	2.0	0.0	0.0	0.0	8.2	4.3	10.0

Table 6.3.25: *Association between seasonal distribution of relative weight loss and gain and gender within the adult (≥18 years) longitudinal sample 1 (n=73)* *a.* χ^2=8.924, df=3, p=0.030; b. χ^2=6.873, df=5; n.s. c. χ^2=4.722, df=4; n.s d. χ^2=2.979, df=5; n.s

Sample 2: Seasonal distribution of relative weight losses and gains by age group									
		Harvest [a]				Post-harvest [b]			
Weight change category	%	Total Pop.	Young adults	Middle-aged	Elderly	Total Pop.	Young adults	Middle-aged	Elderly
Severe loss	≥-7.5	2.5	0	3.3	1.3	4.4	0.0	3.8	8.0
Moderate loss	-5.0 to -7.49	5.3	0	6.6	4.0	15.1	12.9	13.7	20.0
Mild loss	-0.1 to -4.9	38.7	22.6	42.5	34.7	56.6	51.6	59.4	50.7
Mild gain	0.1-4.9	44.0	54.8	38.7	54.7	21.4	35.5	20.3	18.7
Moderate gain	5.0-7.49	6.0	9.7	6.6	2.7	1.9	0.0	2.4	1.3
Large gain	≥7.5	3.5	12.9	2.4	2.7	0.6	0.0	0.5	1.3

Table 6.3.26: *Association between seasonal distribution of relative weight loss and gain and gender within the adult (≥18 years) longitudinal sample 2 (n=318)* *a.* χ^2=22.652, df=10, p=0.012; b. χ^2=11.327, df=10; n.s.

Sample 1: Seasonal prevalence of chronic energy deficiency (CED)													
Nutritional status	**BMI**	**Nov-94[a]**			**Mar-95[b]**			**Jul-95[c]**			**Nov-95[d]**		
classification	**kg/m²**	**Total**	**M**	**F**	**Total**	**M**	**F**	**Total**	**M**	**F**	**Total**	**M**	**F**
CED	<18.5	20.5	39.1	12.0	9.6	26.1	2.0	13.7	34.8	4.0	16.4	34.8	8.0
Adequately nourished	≥18.5	79.5	60.9	88.0	90.4	73.9	98.0	86.3	65.2	96.0	83.6	65.2	92.0

Table 6.4.1: *Association between prevalence of chronic energy deficiency (CED) BMI <18.5 and gender by survey round. Number and percentage (parentheses) of male (n=23) and female adult (n=50) longitudinal sample 1.*

a. χ^2=7.103; df=1; p=0.008 Male RR=3.26; Male OR=4.71
b. χ^2=10.542; df=1; p=0.001 Male RR=10.44; Male OR=17.30
c. χ^2=12.627; df=1; p=<0.001 Male RR=8.695; Male OR=12.69
d. χ^2=8.227; df=1; p=0.004 Male RR=4.348; Male OR=6.13

Sample 1: Seasonal distribution of adult Body Mass Index (BMI)													
Nutritional status	**BMI**	**Nov-94[a]**			**Mar-95[b]**			**Jul-95[c]**			**Nov-95[d]**		
classification	**kg/m²**	**Total**	**M**	**F**	**Total**	**M**	**F**	**Total**	**M**	**F**	**Total**	**M**	**F**
Severe underweight	<16.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moderate underweight	16.0-16.99	5.5	13.0	2.0	2.7	4.3	2.0	1.4	0.0	2.0	8.2	21.7	2.0
Mild underweight	17.0-18.49	15.1	26.1	10.0	6.8	21.7	0.0	12.3	34.8	2.0	8.2	13.0	6.0
Adequate weight	18.5-24.99	57.5	56.5	58.0	64.4	69.6	62.0	58.9	56.5	60.0	61.6	60.9	62.0
Overweight Grade I	25.0-29.99	15.1	4.3	20.0	17.8	4.3	24.0	19.2	8.7	24.0	13.7	4.3	18.0
Obese Grade II	30.0-39.99	5.5	0.0	8.0	6.8	0.0	10.0	6.8	0.0	10.0	6.8	0.0	10.0
Obese Grade III	≥40	1.4	0.0	2.0	1.4	0.0	2.0	1.4	0.0	2.0	1.4	0.0	2.0

Table 6.4.2: *Association between gender and degrees of underweight & overweight within the adult (≥18 years) population longitudinal sample 1*

a. χ^2=11.079 df=5; p=0.050 b.χ^2=17.503 df=5; p=0.004 c. χ^2=18.909 df=5; p=0.002 d.χ^2=13.325; df=5; p=0.021

Sample 2: Seasonal prevalence rate of CED expressed as percentage amongst (≥18 years) by age group and gender									
	Mar-95[a]			Jul-95[b]			Nov-95[c]		
Adulthood	Total	M	F	Total	M	F	Total	M	F
Youth	16.4	23.5	7.1	12.9	23.5	0.0	12.9	17.6	7.1
Middle-aged	4.7	14.3	1.3	6.6	19.6	1.9	9.0	19.6	5.1
Elderly	24.0	29.7	18.4	21.3	29.7	13.2	26.7	37.8	15.8
All	10.4	20.9	4.8	10.7	23.6	3.8	13.5	25.5	6.3

Table 6.4.3: *Seasonal variation of CED (<18.5 kg/m²) and each discrete period of adulthood within the male and female adult population for longitudinal sample 2 (n=318)*

a. All: χ^2=23.371; df=2; p=<0.001 Males: χ^2=3.297; df=2; p= n.s. Females: χ^2=19.792; df=2; p<0.001
b. All: χ^2=12.764; df=2; p=0.002 Males: χ^2=1.256; df=2; p= n.s. Females: χ^2=11.029; df=2; p<0.004
c. All: χ^2=14.861; df=2; p= 0.001 Males: χ^2=4.533; df=2; p= n.s. Females: χ^2=5.191; df=2; p= n.s.

Sample 2: Seasonal distribution of adult Body Mass Index (BMI) amongst whole population										
Nutritional status	BMI	Mar-95[a]			Jul-95[b]			Nov-95[c]		
classification	kg/m²	Total Pop.	M	F	Total Pop.	M	F	Total Pop.	M	F
Severe underweight	<16.0	0.9	2.7	0.0	0.6	0.9	0.5	1.6	1.8	1.4
Moderate underweight	16.0-16.99	1.9	2.7	1.4	2.8	4.5	1.9	3.5	9.1	0.5
Mild underweight	17.0-18.49	7.5	15.5	3.4	7.2	18.2	1.4	8.5	14.5	5.3
Adequate weight	18.5-24.99	68.9	76.4	64.9	68.2	72.7	65.9	69.5	72.7	67.8
Overweight Grade I	25.0-29.99	16.0	2.7	23.1	16.7	3.6	23.6	13.2	1.8	19.2
Obese Grade II	30.0-39.99	3.8	0.0	5.8	3.5	0.0	5.3	2.8	0.0	4.3
Obese Grade III	≥40	0.9	0.0	1.4	0.9	0.0	1.4	0.9	0.0	1.4

Table 6.4.4: *Association between degrees of underweight & overweight and gender within the adult (≥18 years) population by survey round for longitudinal sample 2 (n=318)*

a. χ^2=48.118; df=12; p=<0.001 b. χ^2=54.866; df=12; p<0.001 c. χ^2=45.862; df=6; p<0.001

Sample 2: Seasonal prevalence rate of CED expressed as percentage amongst young adults (18-21.99 years)										
Nutritional status	**BMI**	**Mar-95[a]**			**Jul-95[b]**			**Nov-95[c]**		
classification	**kg/m²**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
CED	<18.5	16.1	23.5	7.1	12.9	23.5	0.0	12.9	17.6	7.1
Adequately nourished	≥18.5	83.9	76.5	92.9	87.1	76.5	100.0	87.1	82.4	92.9

Table 6.4.5: *Association between gender and prevalence of CED amongst young adults by survey round for longitudinal sample 2 (n=31)*

a. χ^2=1.524; df=1; n.s. b. χ^2=3.782; df=1; n.s. c. χ^2=0.754; df=1; n.s.

Sample 2: Seasonal distribution of adult Body Mass Index (BMI) amongst young adult (18-21.99 years)										
Nutritional status	**BMI**	**Mar-95[a]**			**Jul-95[b]**			**Nov-95[c]**		
classification	**kg/m²**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
Severe underweight	<16.0	3.2	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moderate underweight	16.0-16.99	6.5	11.8	0.0	3.2	5.9	0.0	6.5	11.8	0.0
Mild underweight	17.0-18.49	6.5	5.9	7.1	9.7	17.6	0.0	6.5	5.9	7.1
Adequate weight	18.5-24.99	83.9	76.5	92.9	83.9	76.5	92.9	87.1	82.4	92.9
Overweight Grade I	25.0-29.99	0.0	0.0	0.0	3.2	0.0	7.1	0.0	0.0	0.0
Obese Grade II	30.0-39.99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Obese Grade III	≥40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.4.6: *Association between degrees of underweight & overweight and gender within the adult (≥18 years) population by survey round for longitudinal sample 2 (n=31)*

a. χ^2=2.735; df=3; n.s. b. χ^2=4.754; df=3; n.s. c. χ^2=1.763; df=2; n.s.

Sample 2: Seasonal prevalence rate of CED expressed as percentage amongst middle-aged (22-59.99 years)										
Nutritional status	**BMI**	**Mar-95^{a}**			**Jul-95^{b}**			**Nov-95^{c}**		
classification	**kg/m^2**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
CED	<18.5	4.7	14.3	1.3	6.6	19.6	1.9	9.0	19.6	5.1
Adequately nourished	≥18.5	95.3	85.7	98.7	93.4	80.4	98.1	91.0	80.4	94.9

Table 6.4.7: *Association between gender and prevalence of CED amongst middle-aged adults by survey round for longitudinal sample 2 (n=212)*

χ^2=15.503; df=1; p<0.001. b. χ^2=20.978; df=1; p<0.001 c. χ^2=10.640; df=1; p=0.001

Sample 2: Seasonal distribution of adult Body Mass Index (BMI) amongst Middle-aged (22-59.99 years)										
Nutritional status	**BMI**	**Mar-95^{a}**			**Jul-95^{b}**			**Nov-95^{c}**		
classification	**kg/m^2**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
Severe underweight	<16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moderate underweight	16.0-16.99	0.5	1.8	0.0	0.9	1.8	0.6	1.9	7.1	0.0
Mild underweight	17.0-18.49	4.2	12.5	1.3	5.7	17.9	1.3	7.1	12.5	5.1
Adequate weight	18.5-24.99	68.4	83.9	62.8	67.0	78.6	62.8	68.4	78.6	64.7
Overweight Grade I	25.0-29.99	20.8	1.8	27.6	20.3	1.8	26.9	17.5	1.8	23.1
Obese Grade II	30.0-39.99	5.2	0.0	7.1	5.2	0.0	7.1	4.2	0.0	5.8
Obese Grade III	≥40	0.9	0.0	1.3	0.9	0.0	1.3	0.9	0.0	1.3

Table 6.4.8: *Association between degrees of underweight & overweight and gender amongst the middle-aged population (22-59.99 years) by survey round for longitudinal sample 2 (n=212)*

a. χ^2=39.604; df=5; p<0.001 b. χ^2=30.112; df=5; p<0.001 c. χ^2=35.546; df=5; p<0.001

Sample 2: Seasonal prevalence rate of CED expressed as percentage amongst Elderly (≥60 years)										
Nutritional status	**BMI**	**Mar-95[a]**			**Jul-95[b]**			**Nov-95[c]**		
classification	**kg/m²**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
CED	<18.5	24.0	29.7	18.4	21.3	29.7	13.2	26.7	37.8	15.8
Adequately nourished	≥18.5	76.0	70.3	81.6	78.7	70.3	86.8	73.3	62.2	84.2

Table 6.4.9: *Association between gender and prevalence of CED amongst elderly ≥60 years by survey round for longitudinal sample 2 (n=75)*

a. χ^2=1.314; df=1; n.s. b. χ^2=3.068; df=1; n.s. c. χ^2=4.660; df=1; *p*=0.031

Sample 2: Seasonal distribution of adult Body Mass Index (BMI) amongst Elderly (≥60 years)										
Nutritional status	**BMI**	**Mar-95[a]**			**Jul-95[b]**			**Nov-95[c]**		
classification	**kg/m²**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**	**Total Pop.**	**M**	**F**
Severe underweight	<16.0	2.7	5.4	0.0	2.7	2.7	2.6	6.7	5.4	7.9
Moderate underweight	16.0-16.99	4.0	0.0	7.9	8.0	8.1	7.9	6.7	10.8	2.6
Mild underweight	17.0-18.49	17.3	24.3	10.5	10.7	18.9	2.6	13.3	21.6	5.3
Adequate weight	18.5-24.99	64.0	64.9	63.2	65.3	62.2	68.4	65.3	59.5	71.1
Overweight Grade I	25.0-29.99	9.3	5.4	13.2	12.0	8.1	15.8	6.7	2.7	10.5
Obese Grade II	30.0-39.99	1.3	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0
Obese Grade III	≥40	1.3	0.0	2.6	1.3	0.0	2.6	1.3	0.0	2.6

Table 6.4.10: *Association between degrees of underweight & overweight and gender amongst the elderly population (≥60 years) by survey round for longitudinal sample 2 (n=75)*

a. χ^2=10.197; df=6; n.s. b. χ^2=6.672; df=5; n.s. c. χ^2=8.898; df=5; n.s.

Sample 1: Association between nutritional status according to BMI at start of study (Nov-94) and seasonal delta weight (kg)											
Nutritional status (Nov-94)	**Nov-94 BMI kg/m²**	**Total Pop. n=73**		**Male n=23**		**Female n=50**		**Main effect**	**df**	**F**	***p***
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
		Pre-harvest delta weight (kg)									
CED	<18.5	1.9	2.1	1.7	2.7	2.2	1.0				
Adequately nourished	18.5-24.99	2.3	1.7	2.2	2.0	2.4	1.6				
Overweight/Obesity	≥25	2.7	2.1	1.3		2.8	2.1				
All		2.3	1.9	2.0	2.2	2.5	1.7	Delta weight	2	6.121	0.003
		Harvest delta weight (kg)						Delta weight *age	2	6.460	0.002
CED	<18.5	0.3	2.3	0.3	2.6	0.4	1.9	Delta weight *BMI category	4	0.519	n.s.
Adequately nourished	18.5-24.99	-0.6	2.5	-0.8	2.5	-0.5	2.5	Delta weight *gender	2	0.066	n.s.
Overweight/Obesity	≥25	-0.4	1.7	0.9		-0.5	1.7	Delta weight *BMI category*gender	4	0.438	n.s.
All		-0.4	2.3	-0.3	2.5	-0.4	2.2				
		Post-harvest delta weight (kg)									
CED	<18.5	-1.5	1.8	-1.5	2.3	-1.3	0.9				
Adequately nourished	18.5-24.99	-1.3	2.1	-1.7	1.7	-1.2	2.2				
Overweight/Obesity	≥25	-2.0	1.9	-4.0		-1.8	1.9				
All		-1.5	2.0	-1.8	1.9	-1.4	2.0				

Table 6.4.11: *Repeat measures ANCOVA comparing within-subject effects of initial nutritional status and gender on seasonal change in delta weight (kg) controlling for age using longitudinal sample 1 (n=73)*

Sample 1: Association between nutritional status according to BMI at start of study (Nov-94) and inter-annual delta weight (kg)											
Nutritional status (Nov-94)	**Nov-94 BMI kg/m²**	**Total Pop. n=73**		**Male n=23**		**Female n=50**		**Main effect**	**df**	**F**	***p***
		Mean*	**SD**	**Mean***	**SD**	**Mean***	**SD**				
		Inter-annual delta weight (kg)									
CED	<18.5	0.8	2.8	0.4	3.4	1.3	1.5	Age	1	0.289	n.s.
Adequately nourished	18.5-24.99	0.4	2.4	-0.3	1.7	0.7	2.6	BMI category	2	0.612	n.s.
Overweight/Obesity	≥25	0.3	2.3	-1.8		0.5	2.3	Gender	1	1.567	n.s.
All		0.5	2.4	-0.5	4.4	0.8	3.1	BMI category * gender	2	0.131	n.s.

Table 6.4.12: *One-way ANCOVA comparing within-subject effects of initial nutritional status and gender on inter-annual change in delta weight (kg) controlling for age using longitudinal sample 1 (n=73).*

Sample 2: Association between nutritional status according to BMI at start of study (Mar-95) and seasonal delta weight (kg)							
		Total Pop.		Main effect	df	F	*p*
		Harvest **delta weight (kg)**					
		Mean	**SD**				
Severely/Moderately CED	<17.00	0.8	2.2	Age	1	0.011	0.915
Mild CED	17-18.49	0.7	2.2	BMI category	4	3.688	0.006
Adequately nourished	18.5-24.99	0.03	2.2				
Overweight	25.00-29.99	0.2	2.2				
Obesity	≥30	-1.9	2.2				
All							
		Post-harvest **delta weight (kg)**					
		Mean	**SD**				
Severely/Moderately CED	<17.00	-1.1	2.0	Age	1	6.461	0.012
Mild CED	17-18.49	-0.5	2.0	BMI category	4	2.147	n.s.
Adequately nourished	18.5-24.99	-1.3	2.0				
Overweight	25.00-29.99	-1.9	2.0				
Obesity	≥30	-0.9	2.0				
All							

Table 6.4.13: *One-way ANCOVA comparing between-subject effects of initial nutritional status and on seasonal change in delta weight (kg) controlling for age using longitudinal sample 2 (n=318)*

Figures for Chapter 6

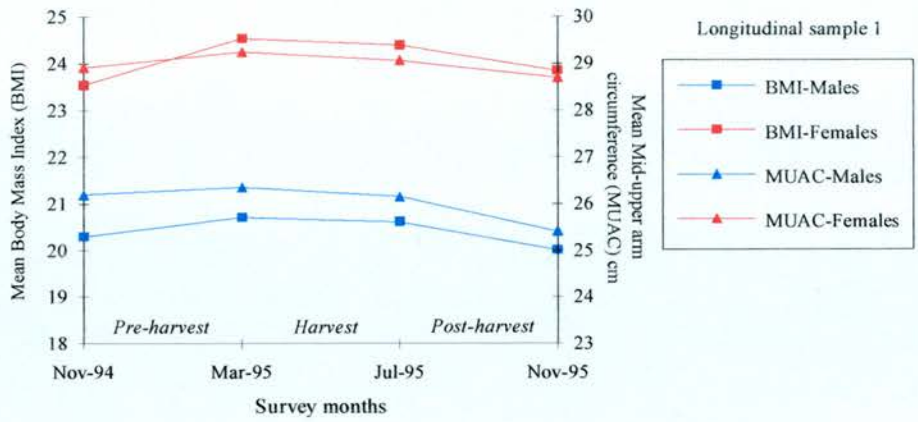

Figure 6.1: *Male and female adjusted mean Body Mass Index (BMI) and Mid-upper arm circumference (MUAC) by survey month for longitudinal sample 1 (n=73)*

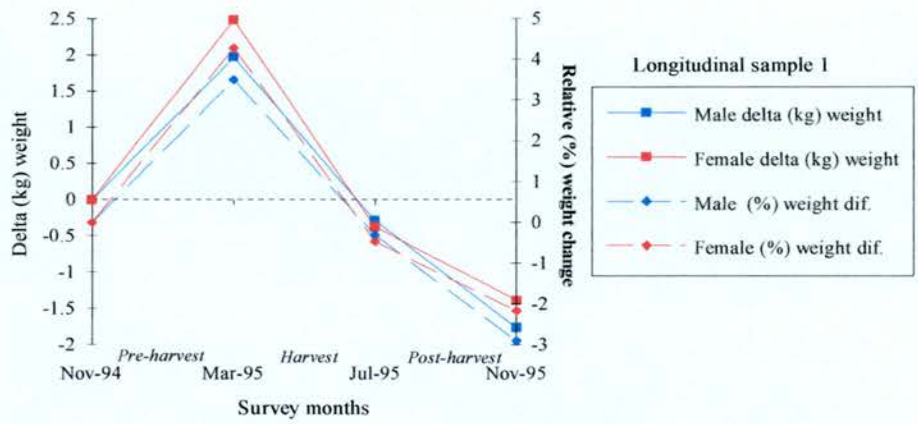

Figure 6.2 *Male and female adjusted mean absolute (kg) and relative (%) pre-harvest, harvest and post-harvest seasonal weight differences for longitudinal sample 1 (n=73)*

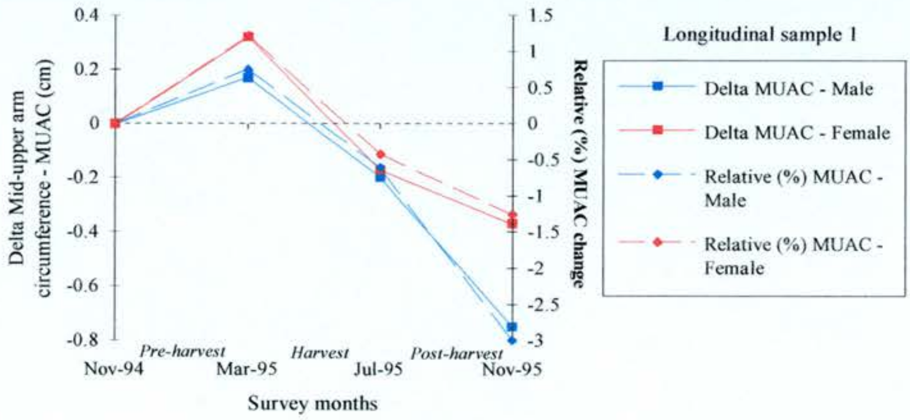

Figure 6.3: *Male and female adjusted mean absolute (cm) and relative (%) pre-harvest, harvest and post-harvest seasonal MUAC differences for longitudinal sample 1 (n=73)*

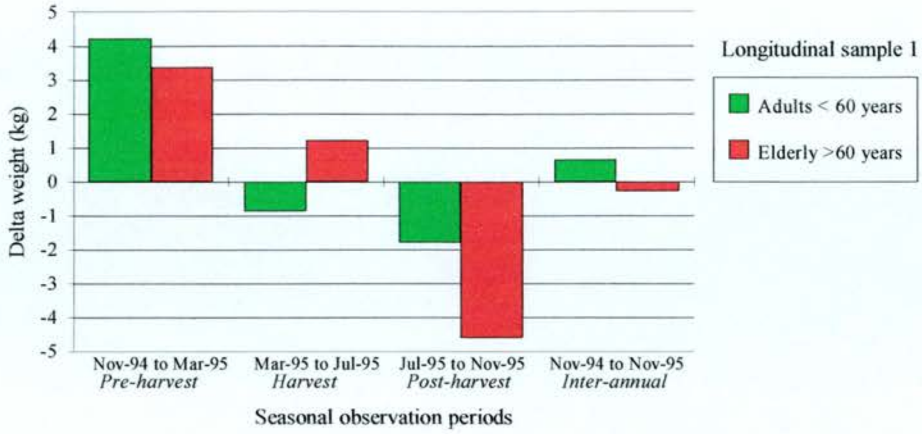

Figure 6.4: *Comparison middle-aged (18-59.99 years) and elderly (≥60 years) mean absolute seasonal weight (kg) changes for longitudinal sample 1 (n=73)*

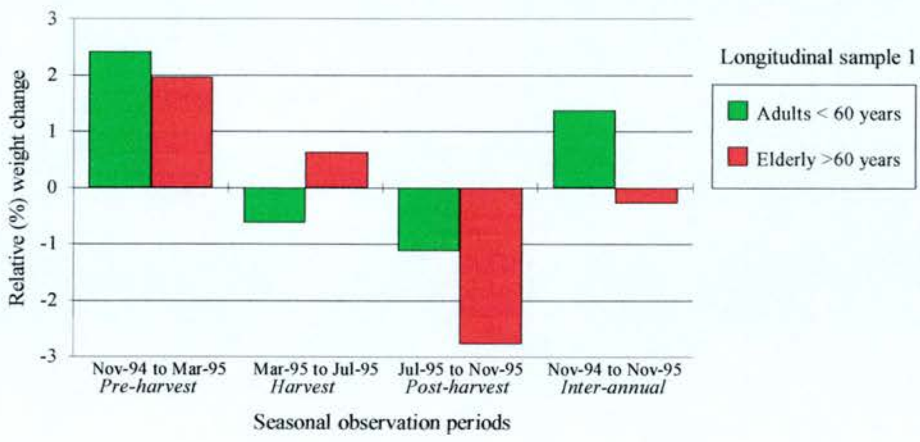

Figure 6.5: *Comparison middle-aged (18-59.99 years) and elderly (≥60 years) mean relative seasonal weight (kg) changes for longitudinal sample 1 (n=73)*

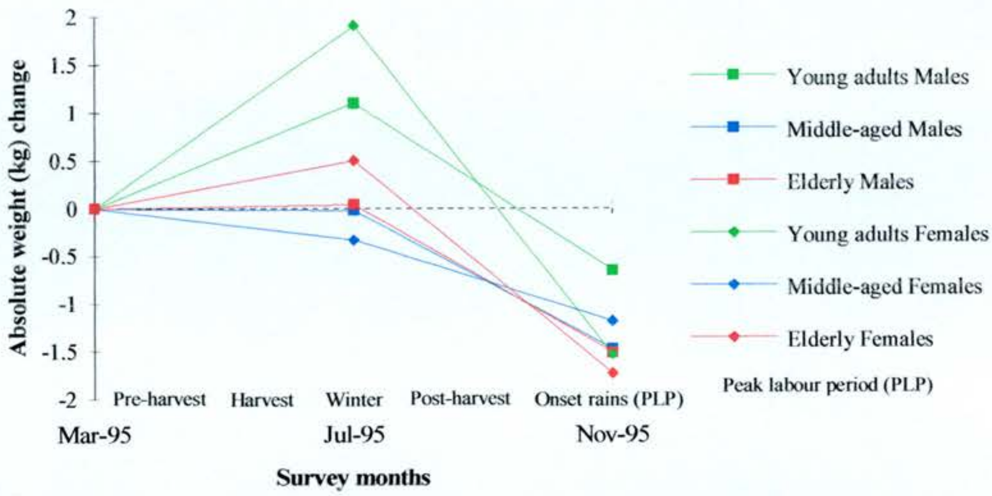

Figure 6.6: *Seasonal absolute weight (kg) change for males and females by age group longitudinal sample 2 (n=318)*

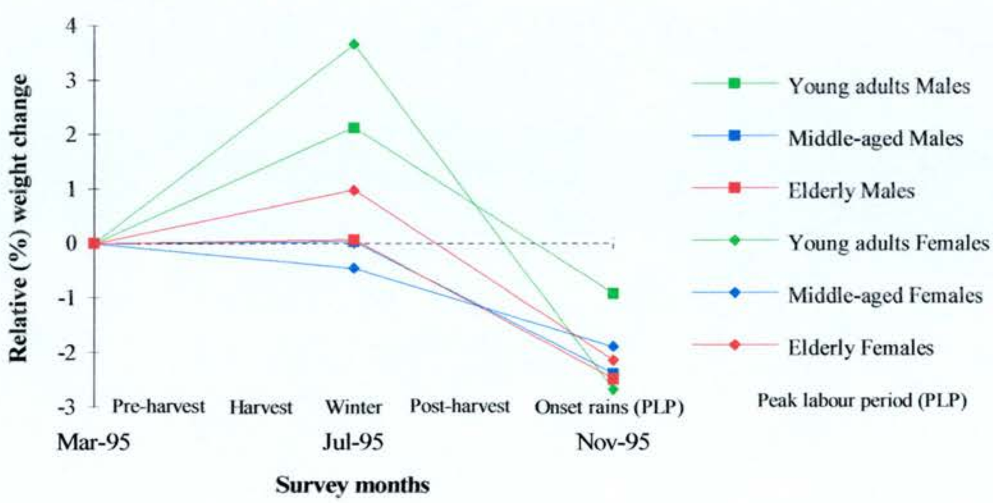

Figure 6.7: *Seasonal relative weight (%) change for males and females by age group longitudinal sample 2 (n=318)*

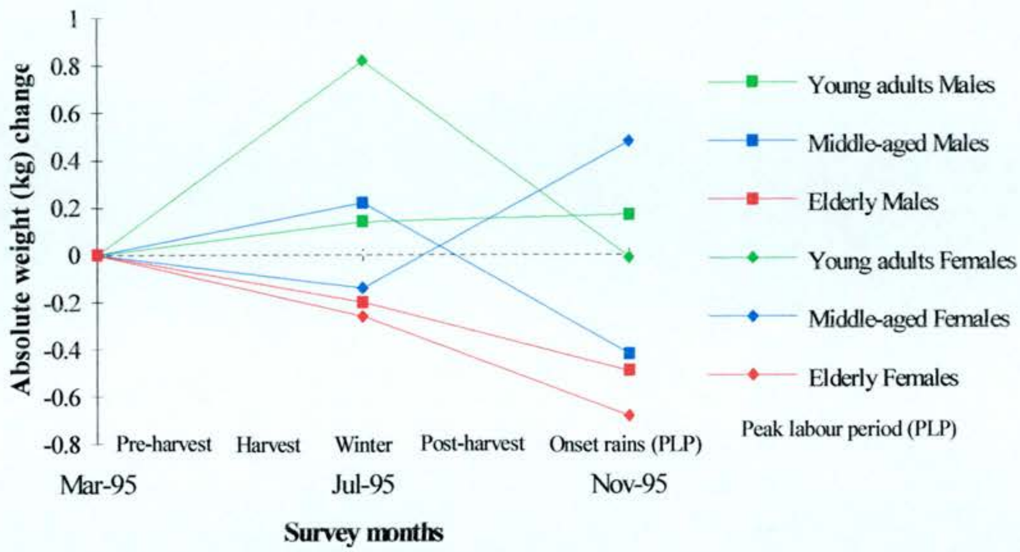

Figure 6.8: *Seasonal absolute MUAC (cm) change for males and females by age group for longitudinal sample 2 (n=318)*

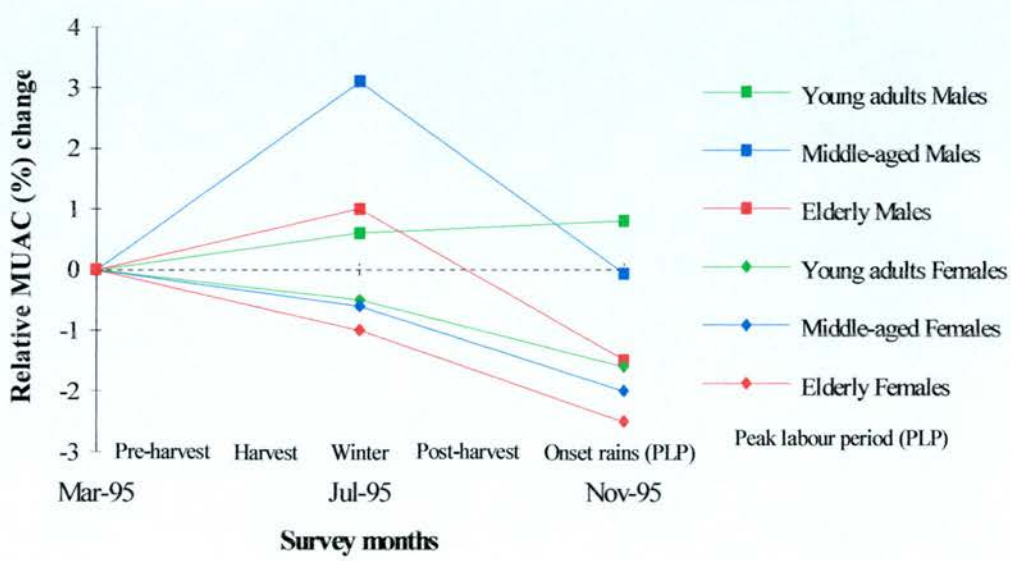

Figure 6.9: *Seasonal relative MUAC (%) change for males and females by age group for longitudinal sample 2 (n=318)*

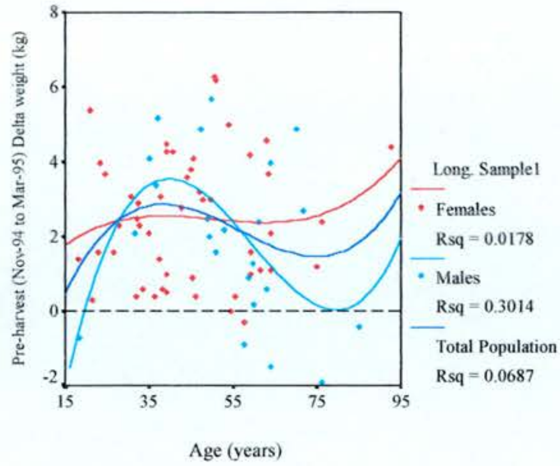

Figure 6.10: *Cubic regression (best fitting line) for male and female adult* ***pre-harvest*** *(Nov-94 to Mar-95) delta weight (kg) for Longitudinal sample 1 (n=73)*

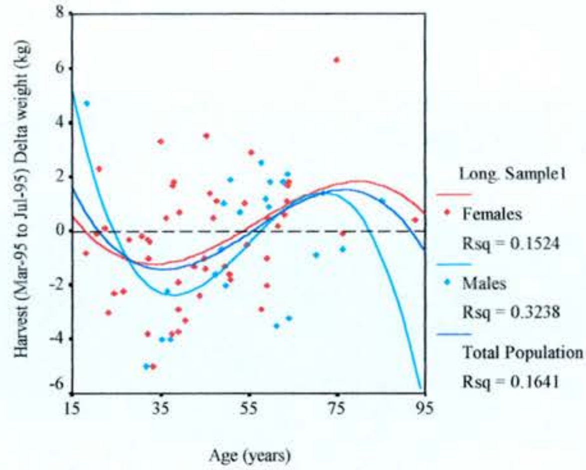

Figure 6.11: *Cubic regression (best fitting line) for male and female adult* ***harvest*** *(Mar-95 to Jul-95) delta weight (kg) for Long. sample 1 (n=73)*

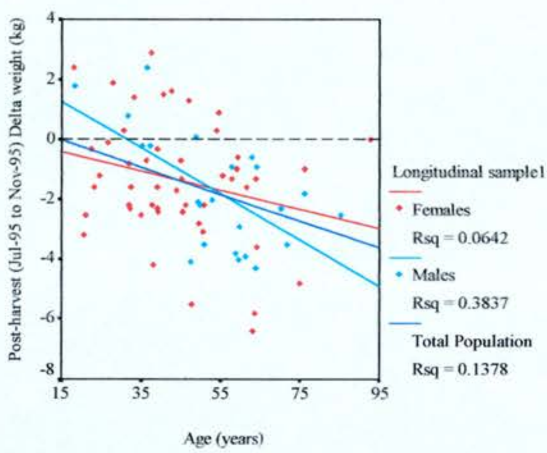

Figure 6.12: Linear *regression (best fitting line) for male and female adult* ***post-harvest*** *(Jul-95 to Nov-95) delta weight (kg) for Longitudinal sample 1*

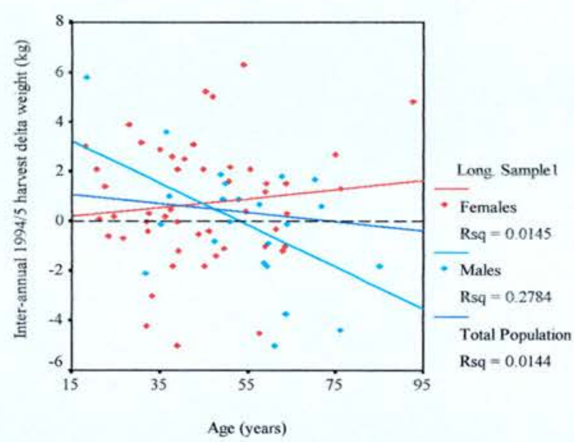

Figure 6.13: Linear *regression (best fitting line) for male and female adult* ***inter-annual*** *(Nov-94 to Nov-95) delta weight (kg) for Longitudinal sample 1 (n=73)*

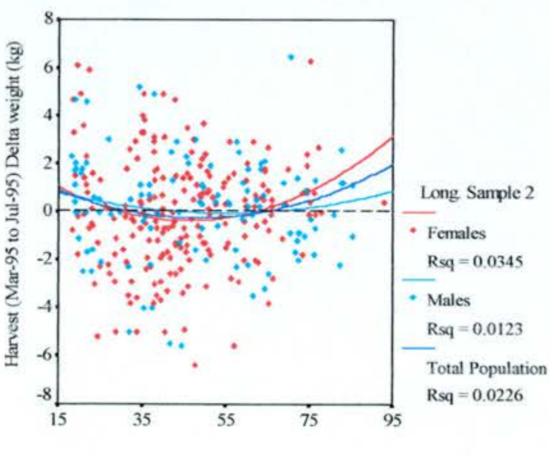

Figure 6.14: Quadratic *regression (best fitting line) for male and female adult* ***harvest*** *(Mar-95 to Jul-95) delta weight (kg) for Longitudinal sample 2 (n=318)*

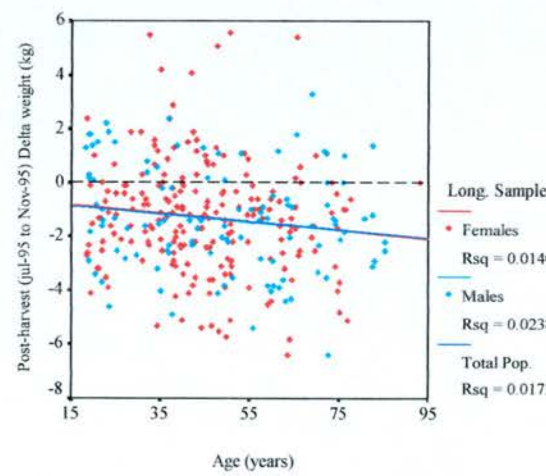

Figure 6.15: Linear *regression (best fitting line) for male and female adult* ***post-harvest*** *(Jul-95 to Nov-95) delta weight (kg) for Longitudinal sample 2 (n=318)*

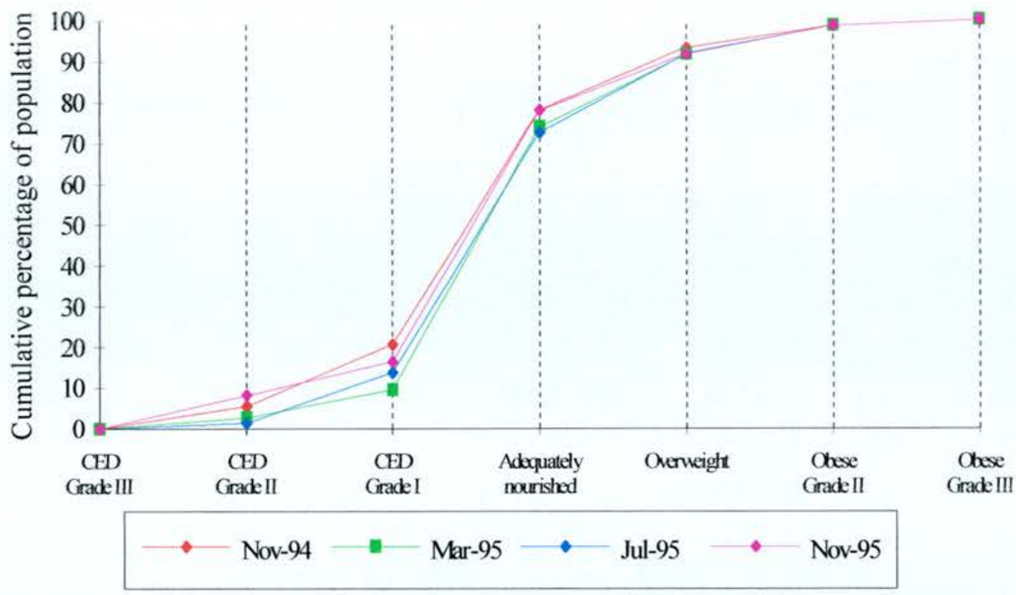

Figure 6.16 *Seasonal distribution of adult BMI Nov-94-Nov-95 for longitudinal sample 1=73*

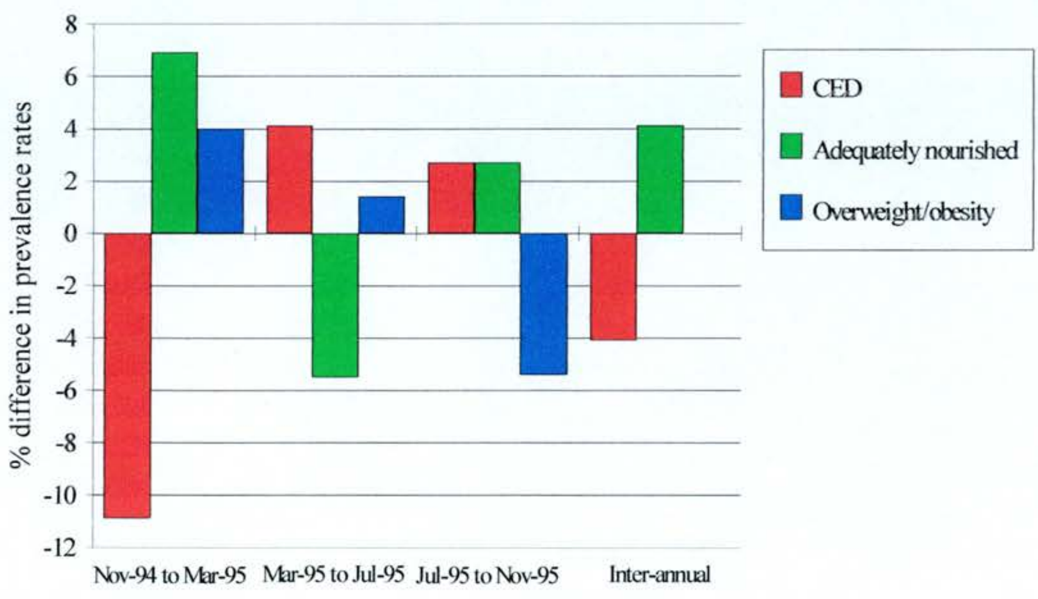

Figure 6.17: *The seasonal change in the prevalence rates of chronic energy deficiency (CED), adequate nourishment and overweight or obesity*

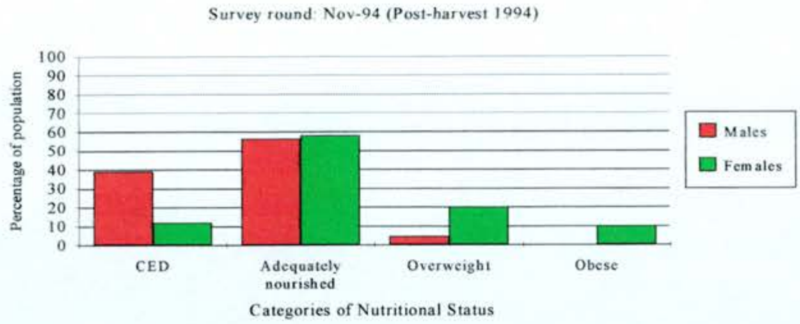

***Figure 6.18**: Proportion of population categorised as CED, adequately nourished, overweight or obese by gender in Nov-94 (Post-harvest month 1994 agricultural season) for longitudinal sample 1*

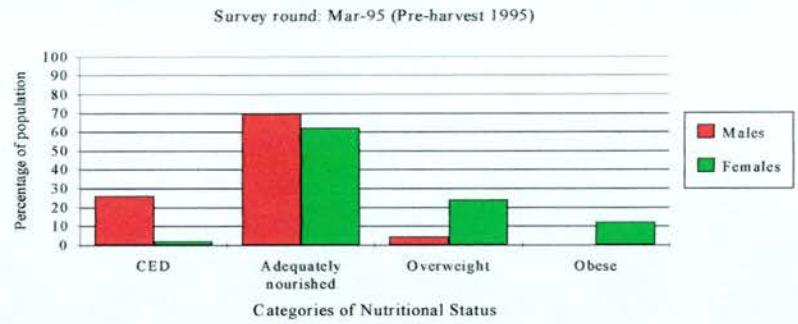

***Figure 6.19:** Proportion of population categorised as CED, adequately nourished, overweight or obese by gender in Mar-95 (Pre-harvest month 1995 agricultural season) for longitudinal sample 1*

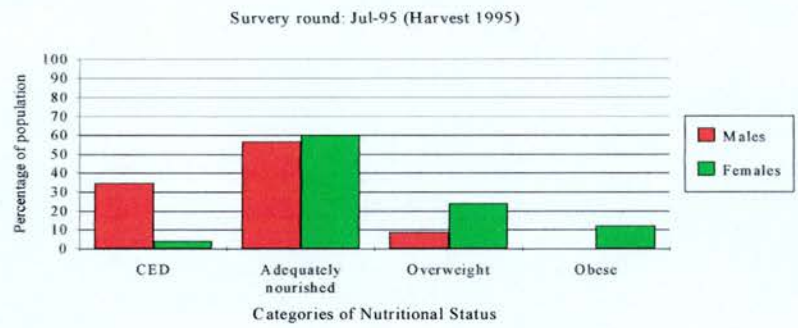

***Figure 6.20:** Proportion of population categorised as CED, adequately nourished, overweight or obese by gender in Jul-95 (Harvest month 1995 agricultural season) for longitudinal sample 1*

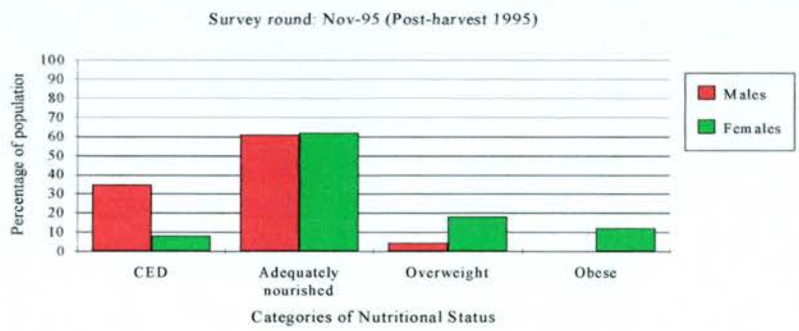

***Figure 6.21:** Proportion of population categorised as CED, adequately nourished, overweight or obese by gender in Novl-95 (Post-harvest month 1995 agricultural season) for longitudinal sample 1*

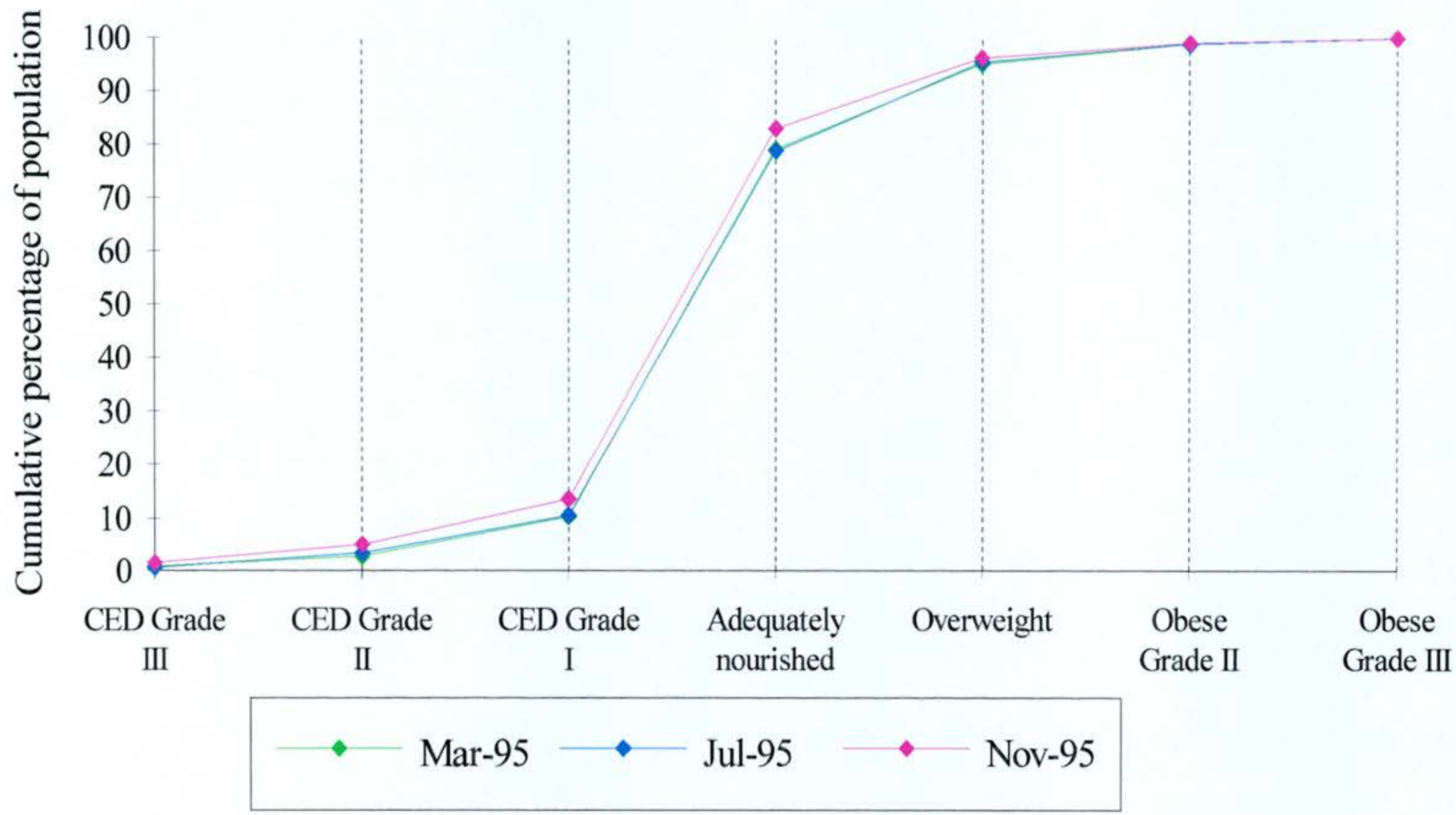

Figure 6.22 *Seasonal distribution of adult BMI Mar-95 to Nov-95 for longitudinal sample 2 n=318*

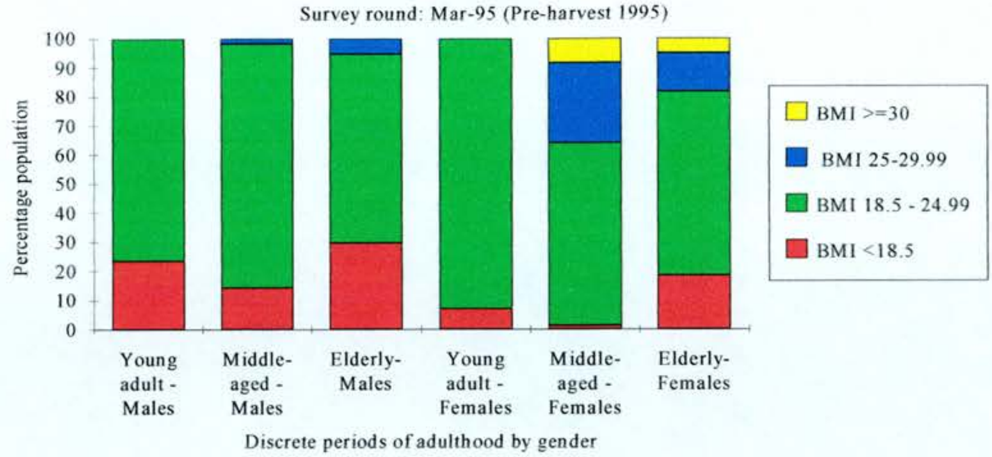

Figure 6.23: *Proportion of population categorised as CED, adequately nourished, overweight or obese by gender and age group in Mar-95 (Pre-harvest month 1995 agricultural season) for longitudinal sample 2*

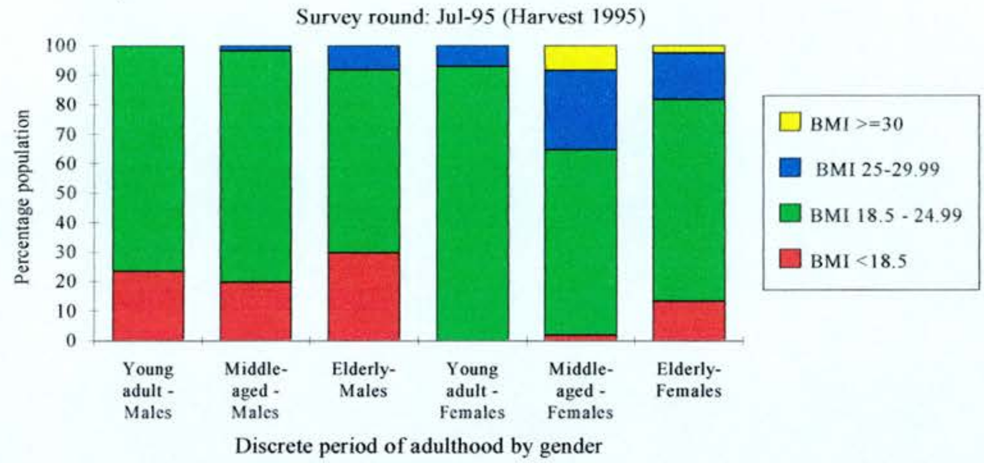

Figure 6.24: *Proportion of population categorised as CED, adequately nourished, overweight or obese by gender and age group in Jul-95 (Harvest month 1995 agricultural season) for longitudinal sample 2*

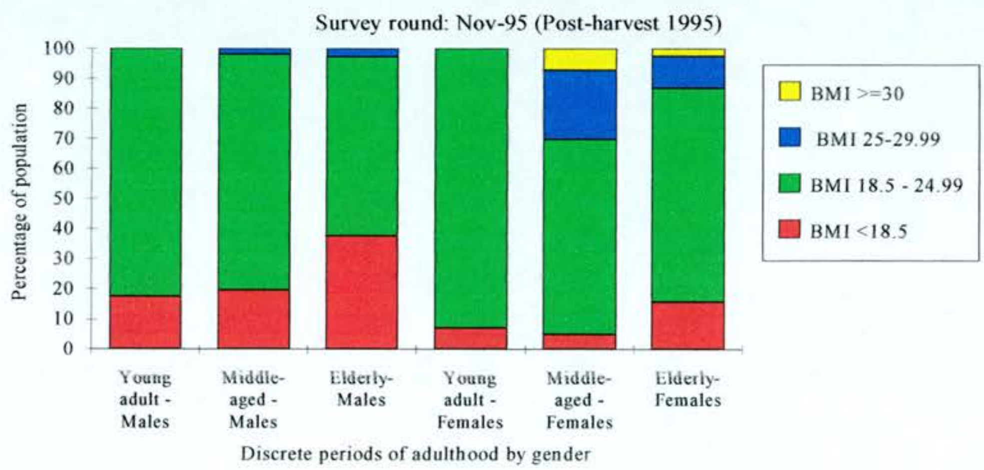

Figure 6.25: *Proportion of population categorised as CED, adequately nourished, overweight or obese by gender and age group in Nov-95 (Post-harvest month 1995 agricultural season) for longitudinal sample 2*

Tables for Section 6.6

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal weight (kg) increments by age group and gender

		Pre-harvest		*Harvest*		*Post-harvest*					
	n	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Pre-school											
Male	24	0.99	0.9	0.71	0.8	0.32	1.0				
Females	31	0.78	0.9	1.19	0.8	0.24	1.0				
All	**55**	0.89	0.9	0.95	0.8	0.28	1.0				
Primary school								Absolute weight change	3	39.660	<0.001
Males	33	1.18	0.9	0.86	0.8	0.12	1.0	Absolute weight change * age group	4	1.297	n.s.
Females	40	1.16	0.9	0.91	0.8	0.20	1.0	Absolute weight change * gender	2	1.273	n.s.
All	**73**	1.17	0.9	0.88	0.8	0.16	1.0	Absolute weight change * age group * gender	4	0.649	n.s.
Adolescent											
Males	24	1.63	0.9	1.06	0.8	0.44	1.0				
Females	36	1.63	0.9	1.30	0.8	0.79	1.0				
All	**60**	1.63	0.9	1.18	0.9	0.62	1.0				
Whole child sample											
Males	81	1.26	0.9	0.88	0.8	0.30	1.0				
Females	107	1.19	0.9	1.13	0.8	0.41	1.0				
All	**188**	1.23	0.9	1.00	0.9	0.35	1.0				

Table 6.6.1: *Repeat measures ANCOVA within-subject effect of age group and gender on 4-monthly estimated mean seasonal absolute weight (kg) increments for the whole child population longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean relative seasonal weight (%) increments by age group and gender											
		Pre-harvest		*Harvest*		*Post-harvest*					
	n	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Pre-school											
Male	24	8.01	5.8	5.03	4.1	2.34	4.0				
Females	31	9.47	5.8	10.84	4.1	2.28	4.0				
All	**55**	8.74	5.8	7.94	4.2	2.31	4.0				
Primary school								% weight change	1.9	44.137	<0.001
Males	33	5.88	5.8	4.17	4.1	0.39	4.0	% weight * age group	3.9	2.839	0.025
Females	40	5.60	5.8	4.47	4.1	0.89	4.0	% weight * gender	1.9	2.191	n.s.
All	**73**	5.74	5.8	4.32	4.2	0.64	4.0	% weight * age group* gender	3.9	1.659	n.s.
Adolescent											
Males	24	4.64	5.8	2.98	4.1	1.67	4.0				
Females	36	4.91	5.8	3.83	4.1	2.20	4.0				
All	**60**	4.77	5.9	3.41	4.2	1.94	4.1				
Whole Pop.											
Males	81	6.18	5.8	4.06	4.2	1.47	4.0				
Females	107	6.66	5.8	6.38	4.2	1.79	4.0				
All	**188**	6.42	5.9	5.22	4.2	1.63	4.0				

Table 6.6.2: *Repeat measures ANCOVA within-subject effect of age group and gender on 4-monthly estimated mean seasonal relative weight (%) increments for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child population estimated mean absolute annual weight (kg) velocity by gender										
Survey	**Total Pop. n=188**		**Male n=81**		**Female n=107**		**Main effect**	**df**	**F**	***p***
round	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	2.57	1.3	2.38	1.3	2.75	1.3	Absolute annual weight increment* age	1	38.132	<0.001
							Absolute annual weight increment* gender	1	4.080	0.045
Longitudinal sample 1: Whole child population estimated mean relative (%) annual weight velocity by gender										
Annual	11.39	5.2	10.49	5.2	12.28	5.2	Relative annual weight change * age	1	65.726	<0.001
							Relative annual weight change* gender	1	5.537	0.020

Table 6.6.3: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (kg) and relative (%) weight velocities for whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean absolute annual weight (kg) velocity by age group and gender							
	Annual			**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**				
Pre-school							
Male	24	2.021	1.2				
Females	31	2.210	1.2				
All	55	2.115	1.3				
Primary school				Absolute annual weight change * age group	2	22.513	<0.001
Males	33	2.164	1.2	Absolute annual weight change * gender	1	2.267	n.s.
Females	40	2.257	1.2	Absolute annual weight change * age group *gender	2	0.678	n.s.
All	73	2.211	1.2				
Adolescent							
Males	24	3.129	1.2				
Females	36	3.717	1.2				
All	60	3.423	1.3				
Whole child sample							
Males	81	2.438	1.3				
Females	107	2.728	1.3				
All	188	2.583	1.3				

Table 6.6.4: *One-way ANOVA between-subject effect of age group and gender on annual absolute weight (kg) velocity for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean relative annual weight (%) velocity by age group and gender							
	Annual			**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**				
Pre-school							
Male	24	13.333	5.1				
Females	31	18.410	5.1				
All	55	15.871	5.2				
Primary school							
Males	33	9.488	5.1	Relative annual weight change* age group	2	32.536	<0.001
Females	40	9.969	5.1	Relative annual weight change * gender	1	7.740	0.006
All	73	9.729	5.2	Relative annual weight change *age group *gender	2	3.337	0.038
Adolescent							
Males	24	8.548	5.1				
Females	36	9.893	5.1				
All	60	9.221	5.2				
Whole child sample							
Males	81	10.456	5.2				
Females	107	12.758	5.2				
All	188	11.607	5.2				

Table 6.6.5: *One-way ANOVA between-subject effect of age group and gender on annual relative annual weight (%) velocity for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Pre-school children (0-4.99 years) estimated mean weight (kg) by gender and survey round										
Survey round	**Total Pop. (n=55)**		**Male (n=24)**		**Female (n=31)**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94	11.7	1.2	12.2	1.3	11.3	1.3	Weight	2.9	47.743	<0.001
Mar-95	12.6	1.4	13.3	1.4	11.9	1.4	Weight * age	2.9	4.242	0.007
Jul-95	13.6	1.5	14.0	1.5	13.2	1.5	Weight * gender	2.9	3.419	0.020
Nov-95	13.8	1.4	14.3	1.5	13.4	1.4				

Table 6.6.6: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal weight (kg) measures for longitudinal sample 1 of pre-school children (n=55)*

Longitudinal sample 1: Pre-school children (0-4.99 years) estimated mean absolute seasonal 4-monthly weight (kg) changes by gender										
Survey round	**Total Pop. (n=55)**		**Male (n=24)**		**Female (n=31)**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	0.899	0.6	1.103	0.6	0.694	0.6	Absolute weight change	2	8.943	<0.001
Harvest	0.943	0.6	0.654	0.7	1.233	0.7	Absolute weight change * age	2	7.256	0.001
Post-harvest	0.281	0.6	0.330	0.6	0.231	0.6	Absolute weight change * gender	2	6.714	0.002
Longitudinal sample 1: Pre-school child (0-4.99 years) estimated mean relative seasonal 4-monthly weight (%) changes by gender										
Pre-harvest	8.96	7.4	10.00	7.5	7.93	7.5	Relative weight change	1.9	15.629	<0.001
Harvest	7.95	6.0	5.12	6.1	10.77	6.1	Relative weight change * age	1.9	10.318	<0.001
Post-harvest	2.34	5.0	2.62	5.1	2.06	5.1	Relative weight change * gender	1.9	4.451	0.015

Table 6.6.7: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal estimated 4-monthly mean absolute weight (kg) and relative weight (%) increments for longitudinal sample 1 of pre-school children (0-4.99 years) (n=55)*

Longitudinal sample 1: Pre-school child estimated mean absolute annual weight (kg) velocity by gender										
Survey round	**Total Pop. (n=55)**		**Male (n=24)**		**Female (n=31)**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	2.12	0.8	2.09	0.8	2.16	0.8	Absolute annual weight change* age	1	3.707	n.s.
							Absolute annual weight change * gender	1	0.099	n.s.
Longitudinal sample 1: Pre-school child estimated mean relative annual weight (%) velocity by gender										
Annual	16.05	5.9	14.93	6.0	17.18	6.0	Relative annual weight change* age	1	40.732	<0.001
							Relative annual weight change * gender	1	1.828	n.s.

Table 6.6.8: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (kg) and relative (%) weight velocity for longitudinal sample 1 of pre-school children (n=55).*

Longitudinal sample 1: Primary school-aged children (5-9.99 years) estimated mean weight (kg) by gender and survey round										
Survey round	Total Pop.(n=73)		Male (n=33)		Female (n=40)		Main effect	df	F	p
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	20.8	2.8	21.0	2.8	20.5	2.8	Weight	2.75	7.826	<0.001
Mar-95	21.9	2.9	21.2	2.9	21.7	2.9	Weight * age	2.75	0.987	n.s.
Jul-95	22.8	3.0	23.0	3.0	22.6	3.0	Weight * gender	2.75	0.169	n.s.
Nov-95	23.0	3.1	23.2	3.1	22.8	3.1				

Table 6.6.9: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal weight (kg) measures for longitudinal sample 1 of primary school-aged children n=73*

Longitudinal sample 1: Primary-school-aged children (5-9.99 years) estimated mean absolute seasonal weight (kg) changes by gender										
Survey round	Total Pop.(n=73)		Male (n=33)		Female (n=40)		Main effect	df	F	p
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.17	0.7	1.18	0.7	1.15	0.7	Absolute weight change	2	3.602	0.030
Harvest	0.88	0.6	0.86	0.6	0.91	0.6	Absolute weight change * age	2	2.194	n.s.
Post-harvest	0.16	0.7	0.13	0.7	0.20	0.7	Absolute weight change * gender	2	0.092	n.s.
Longitudinal sample 1: Primary-school-aged children (5-9.99 years) estimated mean relative seasonal weight (%) changes by gender										
Pre-harvest	5.74	3.6	5.87	3.6	5.61	3.6	Relative weight change	2	7.989	<0.001
Harvest	4.32	2.8	4.14	2.8	4.50	2.8	Relative weight change * age	2	4.036	<0.001
Post-harvest	0.64	3.1	0.40	3.0	0.89	3.0	Relative weight change * gender	2	0.234	n.s.

Table 6.6.10: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal estimated 4-monthly mean absolute weight (kg) and relative weight (%) increments for longitudinal sample 1 of primary school-aged children (5-9.99 years) (n=73)*

Longitudinal sample 1: Pre-school child estimated mean absolute annual weight (kg) velocity by gender										
Survey round	Total Pop.(n=73)		Male (n=33)		Female (n=40)		Main effect	df	F	p
	Mean	SD	Mean	SD	Mean	SD				
Annual	2.21	0.9	2.17	0.9	2.26	0.9	Absolute annual weight change* age	1	0.797	n.s.
							Absolute annual weight change * gender	1	0.179	n.s.
Longitudinal sample 1: Pre-school child estimated mean relative annual weight (%) velocity by gender										
Annual	9.73	3.4	9.46	3.4	9.99	3.4	Relative annual weight change* age	1	7.319	0.009
							Relative annual weight change * gender	1	0.425	n.s.

Table 6.6.11: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (kg) and relative(%) weight velocity for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Adolescent population estimated mean weights (kg) by gender										
Survey	Total Pop.(n=60)		Male (n=24)		Female (n=36)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94	33.5	5.6	32.7	5.6	34.3	5.6	Weight	2.6	0.825	n.s.
Mar-95	35.1	5.9	34.2	5.9	36.0	5.9	Weight * age	2.6	5.432	0.002
Jul-95	36.3	6.0	35.1	6.0	37.4	6.0	Weight * gender	2.6	2.202	n.s.
Nov-95	36.9	5.9	35.6	5.9	38.2	5.8				

Table 6.6.12: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal weight (kg) measures for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Adolescent (10-17.99 years) estimated mean absolute seasonal 4-monthly weight (kg) changes by gender										
Survey	Total Pop.(n=60)		Male (n=24)		Female (n=36)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.60	1.1	1.47	1.1	1.74	1.1	Absolute weight change	2	1.298	n.s.
Harvest	1.12	1.2	0.99	1.2	1.34	1.2	Absolute weight change * age	2	2.560	n.s.
Post-harvest	0.62	1.5	0.47	1.5	0.77	1.5	Absolute weight change * gender	2	0.015	n.s.
Longitudinal sample 1: Adolescent (10-17.99 years) estimated mean relative seasonal 4-monthly weight (%) changes by gender										
Pre-harvest	4.74	3.3	4.47	3.3	5.02	3.3	Relative weight change	2	0.200	n.s.
Harvest	3.41	3.3	3.02	3.3	3.81	3.3	Relative weight change * age	2	0.737	n.s.
Post-harvest	1.96	4.0	1.79	4.0	2.12	4.0	Relative weight change * gender	2	0.046	n.s.

Table 6.6.13: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal estimated 4-monthly mean absolute weight (kg) and relative weight (%) changes for longitudinal sample 1 adolescents (n=60)*

Longitudinal sample 1: Adolescent population estimated mean absolute annual weight (kg) velocity by gender										
Survey	Total Pop.(n=60)		Male (n=24)		Female (n=36)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Annual	3.39	1.8	2.93	1.8	3.85	1.7	Absolute annual weight change* age	1	4.728	0.034
							Absolute annual weight change * gender	1	3.844	n.s.
Longitudinal sample 1: Adolescent population estimated mean relative (%) annual weight velocity by gender										
Annual	9.22	4.2	8.54	4.2	9.90	4.2	Relative annual weight change* age	1	0.091	n.s.
							Relative annual weight change * gender	1	1.430	n.s.

Table 6.6.14: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (kg) and relative (%) weight velocities for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Pre-school child (0-4.99 years) estimated mean absolute seasonal 4-monthly weight (kg) changes by yearly age classes											
Yearly		*Pre-harvest*		*Harvest*		*Post-harvest*					
age class	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
< 1 year	5	1.440	0.7	1.020	0.7	0.200	0.6				
12-23	10	1.130	0.7	0.840	0.7	0.510	0.6	Absolute weight change	1.972	14.096	<0.001
24-35	9	0.822	0.7	0.889	0.7	0.067	0.6	Absolute weight change *	1.972	1.100	n.s.
36-48	15	0.913	0.7	0.987	0.7	0.153	0.6	yearly age classes			
48-59	16	0.525	0.7	1.100	0.7	0.381	0.6				
Longitudinal sample 1: Primary school-aged children (5-9.99 years) estimated mean absolute seasonal 4-mthly wt (kg) changes by yearly age classes											
5-5.99	9	0.889	0.7	1.267	0.6	-0.178	0.7				
6-6.99	14	1.193	0.7	0.993	0.6	0.0357	0.7	Absolute weight change	2	38.523	<0.001
7-7.99	17	1.118	0.7	0.841	0.6	0.259	0.7	Absolute weight change *	2	1.976	0.054
8-8.99	16	1.237	0.7	0.594	0.6	0.556	0.7	yearly age classes			
9-9.99	17	1.271	0.7	0.912	0.6	-0.012	0.7				
Longitudinal sample 1: Adolescent (10.17.99 years) estimated mean absolute seasonal 4-monthly weight (kg) changes by yearly age classes											
10-10.99	17	0.994	1.0	1.276	1.2	0.618	1.4				
11-11.99	10	1.540	1.0	1.090	1.2	0.360	1.4				
12-12.99	12	2.167	1.0	0.600	1.2	1.133	1.4	Absolute weight change	2	12.435	<0.001
13-13.99	5	1.100	1.0	0.920	1.2	0.560	1.4	Absolute weight change *	2	1.475	n.s.
14-14.99	8	1.800	1.0	1.637	1.2	1.275	1.4	yearly age classes			
15-15.99	3	1.833	1.0	2.133	1.2	0.300	1.4				
16-16.99	2	1.700	1.0	1.250	1.2	-1.900	1.4				
17-17.99	3	3.533	1.0	1.900	1.2	0.433	1.4				

Table 6.6.15: *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute weight (kg) changes for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 2: Pre-school estimated mean absolute seasonal 4-monthly weight changes (kg) by yearly age classes and gender														
	Harvest						*Post-harvest*							
Yearly	Male			Female			Male		Female					
age class	n	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Main effect	df	F	*p*
0-11	12	1.61	0.7	14	1.71	0.7	0.54	0.6	0.51	0.6	Absolute weight change	1	62.706	<0.001
12-23	16	0.78	0.7	22	0.76	0.7	0.28	0.6	0.56	0.6	Absolute weight change * yearly age class	4	1.136	n.s.
24-35	14	0.64	0.7	13	0.94	0.6	0.19	0.6	0.29	0.6	Absolute weight change * gender	1	0.002	n.s.
36-48	20	0.84	0.7	19	0.86	0.6	0.21	0.6	0.095	0.6	Absolute weight change * yearly age classes * gender	4	0.918	n.s.
48-59	20	0.84	0.7	30	0.98	0.7	0.39	0.6	0.20	0.6				
Longitudinal sample 2: Primary school-aged population estimated mean absolute seasonal 4-monthly weight changes (kg) by yearly age classes and gender														
5-5.99	21	0.97	0.7	20	1.06	0.7	0.14	0.6	0.015	0.6	Absolute weight change	1	75.547	<0.001
6-6.99	17	0.75	0.7	18	0.93	0.7	0.15	0.7	0.41	0.6	Absolute weight change * yearly age class	4	1.383	n.s.
7-7.99	30	1.07	0.7	29	0.85	0.7	0.14	0.6	0.46	0.6	Absolute weight change * gender	4	0.181	n.s.
8-8.99	19	0.68	0.7	35	0.93	0.7	0.35	0.6	0.31	0.6	Absolute weight change * yearly age classes * gender	1	1.228	n.s.
9-9.99	36	0.83	0.7	26	0.71	0.7	0.28	0.6	0.33	0.6				
Longitudinal sample 2: Adolescent estimated mean absolute seasonal 4-monthly weight changes (kg) by yearly age classes and gender														
10-10.99	27	0.73	1.0	41	1.20	1.0	0.59	1.3	0.71	1.3				
11-11.99	22	0.72	1.0	27	1.30	1.0	0.76	1.3	0.73	1.3	Absolute weight change	1	31.728	<0.001
12-12.99	26	0.60	1.0	29	1.17	1.0	0.30	1.3	0.92	1.3	Absolute weight change * yearly age class	7	2.196	0.035
13-13.99	19	0.98	1.0	17	1.68	1.0	0.96	1.2	0.98	1.3	Absolute weight change * gender	1	0.440	n.s.
14-14.99	21	1.44	1.0	13	1.32	1.0	1.37	1.3	0.80	1.3	Absolute weight change * yearly age classes * gender	7	1.878	n.s.
15-15.99	13	1.34	1.0	15	2.05	1.0	1.37	1.3	0.19	1.3				
16-16.99	13	1.74	1.0	8	0.51	1.0	0.66	1.3	-0.26	1.3				
17-17.99	7	2.09	1.0	5	1.20	1.0	-1.17	1.3	0.20	1.3				

Table 6.6.16: *Repeat measures ANOVA within-subject effect of yearly age classes and gender on* ***harvest*** *and* ***post-harvest*** *seasonal 4-monthly estimated mean absolute weight (kg) changes for longitudinal sample 2: by pre-school (n=180), primary school-aged (n=251) and adolescents (n=303) population*

Longitudinal sample 1: Pre-school estimated mean absolute (kg) and relative (%) annual weight velocity by yearly age classes													
	Annual absolute (kg) weight velocity							Annual relative (%) weight velocity					
	n	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	5	2.66	0.8					30.2	5.5				
12-23	10	2.48	0.8					22.0	5.5				
24-35	9	1.79	0.8	Yearly age classes	4	1.625	n.s.	13.4	5.5	Yearly age classes	4	14.113	<0.001
36-48	15	2.05	0.8					13.4	5.5				
48-59	16	2.01	0.8					12.4	5.5				
Longitudinal sample 1: Primary school-aged population estimated mean absolute (kg) and relative (%) annual weight velocity by yearly age classes													
5-5.99	9	1.98	0.9					11.4	3.4				
6-6.99	14	2.22	0.9					10.8	3.4				
7-7.99	17	2.22	0.9	Yearly age classes	4	0.302	n.s.	10.1	3.4	Yearly age classes	4	2.229	n.s.
8-8.99	16	2.39	0.9					9.7	3.4				
9-9.99	17	2.17	0.9					7.8	3.4				
Longitudinal sample 1: Adolescent population estimated mean absolute (kg) and relative (%) annual weight velocity by yearly age classes													
10-10.99	17	2.89	1.6					8.9	3.9				
11-11.99	10	2.99	1.6					8.9	3.9				
12-12.99	12	3.90	1.6					11.1	3.9				
13-13.99	5	2.58	1.6	Yearly age classes	7	3.126	0.008	7.3	3.9	Yearly age classes	7	1.791	n.s.
14-14.99	8	4.71	1.6					11.2	3.9				
15-15.99	3	4.27	1.6					9.3	3.9				
16-16.99	2	1.05	1.6					2.2	3.9				
17-17.99	3	5.87	1.6					9.9	3.9				

Table 6.6.17: *One-way ANOVA within-subject effect of yearly age classes on estimated mean annual absolute weight (kg) and relative weight (%) velocities for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal height (cm) increments by age group and gender										
	Pre-harvest		*Harvest*		*Post-harvest*		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-school										
Male	1.92	1.3	2.57	1.1	2.33	1.0				
Females	3.43	1.3	2.44	1.1	2.58	1.0				
All	2.67	1.3	2.50	1.1	2.45	1.0				
Primary school							Absolute height change	1.7	1.304	n.s.
Males	1.16	1.3	1.72	1.1	1.60	1.0	Absolute height change * age group	3.5	1.134	n.s.
Females	1.52	1.3	1.91	1.1	1.45	1.0	Absolute height change * gender	1.7	4.988	0.010
All	1.34	1.3	1.82	1.1	1.53	1.0	Absolute height change * age group* gender	3.5	1.787	n.s.
Adolescent										
Males	1.21	1.3	1.54	1.1	1.45	1.0				
Females	1.39	1.3	1.54	1.1	1.25	1.0				
All	1.30	1.4	1.54	1.1	1.35	1.0				
Whole child sample										
Males	1.43	1.4	1.94	1.1	1.80	1.0				
Females	2.11	1.3	1.96	1.1	1.76	1.0				
All	1.77	1.4	1.95	1.1	1.78	1.0				

Table 6.6.18: *Repeat measures ANCOVA within-subject effect of gender and age group on absolute seasonal height (cm) increments for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean relative seasonal height (%) increments by age group and gender											
		Pre-harvest		*Harvest*		*Post-harvest*					
	n	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Pre-school											
Male	24	2.11	1.8	2.74	1.1	2.43	1.0				
Females	31	4.62	1.8	2.87	1.1	3.00	1.0				
All	**55**	3.36	1.9	2.80	1.1	2.71	1.0				
Primary school								% height change	1.9	44.137	n.s.
Males	33	1.00	1.8	1.44	1.1	1.31	1.0	% height change * age group	3.9	2.839	n.s.
Females	40	1.29	1.8	1.59	1.1	1.19	1.0	% height change * gender	1.9	2.191	0.005
All	**73**	1.15	1.8	1.52	1.1	1.25	1.0	% height change * age group* gender	3.9	1.659	0.016
Adolescent											
Males	24	0.84	1.8	1.07	1.1	1.01	1.0				
Females	36	1.00	1.8	1.10	1.1	0.90	1.0				
All	**60**	0.92	1.9	1.09	1.2	0.95	1.0				
Whole Pop.											
Males	81	1.32	1.9	1.75	1.2	1.58	1.0				
Females	107	2.31	1.9	1.85	1.1	1.69	1.0				
All	**188**	1.81	1.9	1.80	1.2	1.64	1.0				

Table 6.6.19: *Repeat measures ANCOVA within-subject effect of gender and age group on relative seasonal height (%) increments for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole population estimated mean absolute (cm) and relative (%) annual height velocity by gender												
	Annual absolute height (cm) velocity						Annual relative height (%) velocity					
	Mean	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Males	5.27	1.5	Absolute annual height increment* age	1	201.570	<0.001	4.96	1.9	Absolute annual height increment* age	1	390.634	<0.001
Female	5.54	1.7	Absolute annual height increment* age^2	1	14.824	<0.001	5.46	1.9	Absolute annual height increment* age^2	1	97.719	<0.001
Total Pop.	5.41	1.5	Absolute annual height increment* age^3	1	31.080	<0.001	5.21	1.9	Absolute annual height increment* age^3	1	63.216	<0.001
			Absolute annual height increment* gender	1	1.329	n.s.			Absolute annual height increment* gender	1	3.002	n.s.

Table 6.6.20: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) height velocity for longitudinal sample 1 of adolescents (n=188)*

Longitudinal sample 1: Whole child sample estimated mean absolute annual height (cm) velocities by age group and gender							
	Annual			**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**				
Pre-school							
Male	24	6.81	1.7				
Females	31	8.45	1.7				
All	55	7.63	1.8				
Primary school				Absolute annual height change* age group	2	70.242	<0.001
Males	33	4.49	1.7	Absolute annual height change* gender	1	6.042	0.015
Females	40	4.88	1.7	Absolute annual height change* age group *gender	2	3.410	0.035
All	73	4.68	1.7				
Adolescent							
Males	24	4.20	1.7				
Females	36	4.19	1.7				
All	60	4.19	1.8				
Whole sample							
Males	81	5.17	1.8				
Females	107	5.83	1.7				
All	188	5.50	1.8				

Table 6.6.21: *Repeat measures ANCOVA within-subject effect of gender and age group on annual absolute annual height (cm) velocities for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean relative annual height (%) velocities by age group and gender							
	Annual			**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**				
Pre-school							
Male	24	7.44	2.6				
Females	31	10.86	2.6				
All	55	9.15	2.6				
Primary school							
Males	33	3.80	2.6	Relative annual height change* age group	2	102.289	<0.001
Females	40	4.12	2.6	Relative annual height change* gender	1	9.375	0.003
All	73	3.96	2.6	Relative annual height change* age group *gender	2	7.369	0.001
Adolescent							
Males	24	2.94	2.6				
Females	36	3.04	2.6				
All	60	2.99	2.6				
Whole sample							
Males	81	4.73	2.6				
Females	107	6.01	2.6				
All	188	5.37	2.6				

Table 6.6.22: *Repeat measures ANOVA within-subject effect of age group and gender on relative annual height (%) velocities for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Pre-school estimated mean height (m) measures by gender and survey round										
Survey round	**Total Pop. n=55**		**Male n=31**		**Female n=24**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94	0.871	3.6	0.881	3.6	0.862	3.6	Height	2.483	115.305	<0.001
Mar-95	0.899	3.2	0.904	3.3	0.893	3.2	Height * age	2.483	8.995	<0.001
Jul-95	0.923	3.3	0.929	3.3	0.918	3.3	Height * gender	2.483	2.126	n.s.
Nov-95	0.948	3.3	0.953	3.4	0.943	3.4				

Table 6.6.23: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal height (m) measures for pre-school children (n=55)*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly height changes (cm) by gender										
Survey round	**Total Pop. n=55**		**Male n=24**		**Female n=31**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	2.71	1.7	2.26	1.7	3.16	1.7	Absolute height change	1.714	7.168	0.002
Harvest	2.49	1.5	2.51	1.5	2.48	1.5	Absolute height change * age	1.714	7.354	0.002
Post-harvest	2.46	1.2	2.37	1.2	2.54	1.2	Absolute height change * gender	1.714	1.179	n.s.
Longitudinal sample 1: Pre-school estimated mean relative seasonal 4-monthly height changes (%) by gender										
Pre-harvest	3.44	2.6	2.76	2.6	4.11	2.6	Relative height change	1.48	11.964	<0.001
Harvest	2.81	1.8	2.80	1.8	2.82	1.8	Relative height change * age	1.48	10.525	<0.001
Post-harvest	2.73	1.4	2.60	1.4	2.86	1.4	Relative height change * gender	1.48	1.465	n.s.

Table 6.6.24: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal adjusted mean 4-monthly absolute height (cm) and relative height (%) increments for longitudinal sample 1 of pre-school children (n=55)*

Longitudinal sample 1: Pre-school population estimated mean absolute (cm) and relative (%) annual height velocity by gender												
	Annual absolute height (cm) velocity						**Annual relative height (%) velocity**					
	Mean	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Males n=24	7.39	1.7	Absolute annual height increment* age	1	28.093	<0.001	8.93	2.4	Absolute annual height increment* age	1	97.591	<0.001
Female n=31	7.99	1.6	Absolute annual height increment* age²	1	11.192	0.002	9.71	2.4	Absolute annual height increment* age²	1	32.705	<0.001
Total Pop. n=55	7.69	1.6	Absolute annual height increment* age³	1	19.250	<0.001	9.32	2.3	Absolute annual height increment* age³	1	35.957	<0.001
			Absolute annual height increment* gender	1	1.716	n.s.			Absolute annual height increment* gender	1	1.360	n.s.

Table 6.6.25: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) height velocities for longitudinal sample 1 of pre-school children (n=55)*

Longitudinal sample 1: Primary school estimated mean height (m) measures by gender and survey round										
Survey round	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	1.197	0.50	1.204	0.50	1.191	0.50	Height	2.6	52.207	<0.001
Mar-95	1.211	0.50	1.215	0.50	1.206	0.50	Height * age	2.6	6.687	0.001
Jul-95	1.229	0.51	1.233	0.51	1.226	0.51	Height * gender	2.6	2.379	n.s.
Nov-95	1.244	0.52	1.249	0.51	1.240	0.51				

Table 6.6.26: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal height (m) measures for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Primary school estimated absolute seasonal 4-monthly height (cm) changes by gender										
Survey round	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.34	0.9	1.16	0.9	1.52	0.9	Absolute height change	2	0.918	n.s.
Harvest	1.82	0.9	1.72	0.9	1.91	0.9	Absolute height change * age	2	1.322	n.s.
Post-harvest	1.53	0.7	1.60	0.7	1.45	0.7	Absolute height change * gender	2	1.395	n.s.
Longitudinal sample 1: Primary school estimated mean relative seasonal 4-monthly height (%) changes by gender										
Pre-harvest	1.146	0.8	0.993	0.8	1.298	0.8	Relative height change	1.8	1.035	n.s.
Harvest	1.516	0.7	1.439	0.7	1.592	0.7	Relative height change * age	1.8	1.252	n.s.
Post-harvest	1.249	0.6	1.307	0.6	1.192	0.6	Relative height change * gender	1.8	1.260	n.s.

Table 6.6.27: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal estimated mean 4-monthly absolute height (cm) and relative height (%) increments for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Primary school estimated mean absolute annual height (cm) velocity by gender										
Survey round	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	4.68	1.0	4.48	1.0	4.88	1.0	Absolute annual height change* age	1	12.669	0.001
							Absolute annual height change * gender	1	2.754	n.s.
Longitudinal sample 1: Primary school estimated mean relative annual height (%) velocity by gender										
Annual	3.96	0.9	3.79	0.9	4.13	0.9	Relative annual height change* age	1	39.520	<0.001
							Relative annual height change * gender	1	2.735	n.s.

Table 6.6.28: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) height velocities for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Adolescent estimated mean height (m) measures by gender and survey round										
Survey round	Total Pop. n=60		Male n=24		Female n=36		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	1.430	7.7	1.438	7.7	1.423	7.7	Height	1.96	48.537	<0.001
Mar-95	1.444	7.7	1.451	7.7	1.436	7.7	Height * age	1.96	19.972	<0.001
Jul-95	1.459	7.7	1.468	7.7	1.451	7.7	Height * gender	1.96	1.951	n.s.
Nov-95	1.473	7.5	1.484	7.5	1.462	7.5				

Table 6.6.29: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal height (m) measures for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Adolescent estimated mean absolute seasonal 4-monthly height changes (cm) by gender										
Survey round	Total Pop. n=60		Male n=24		Female n=36		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.31	1.0	1.27	1.0	1.34	1.0	Absolute height change	2	1.598	n.s.
Harvest	1.56	0.9	1.68	0.9	1.44	0.9	Absolute height change * age	2	1.395	n.s.
Post-harvest	1.38	0.9	1.61	0.9	1.15	0.9	Absolute height change * gender	2	1.141	n.s.
Longitudinal sample 1: Adolescent estimated mean relative seasonal 4-monthly height changes (%) by gender										
Pre-harvest	0.93	0.7	0.90	0.7	0.96	0.7	Relative height change	2	1.350	n.s.
Harvest	1.10	0.6	1.18	0.6	1.03	0.6	Relative height change * age	2	1.171	n.s.
Post-harvest	0.97	0.6	1.13	0.6	0.82	0.6	Relative height change * gender	2	1.058	n.s.

Table 6.6.30: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal estimated mean 4-monthly absolute height (cm) and relative (%) height increments for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Adolescents estimated mean absolute annual height velocity (cm) by gender										
Survey round	Total Pop. n=60		Male n=24		Female n=36		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	4.25	1.6	4.57	1.6	3.94	1.6	Absolute annual height change* age	1	25.391	<0.001
							Absolute annual height change * gender	1	2.105	n.s.
Longitudinal sample 1: Adolescents estimated mean relative annual height velocity (%) by gender										
Annual	3.04	1.2	3.24	1.2	2.84	1.1	Relative annual height change* age	1	33.611	<0.001
							Relative annual height change * gender	1	1.665	n.s.

Table 6.6.31: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) height velocities for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly height (cm) changes by yearly age classes										
		Pre-harvest		*Harvest*		*Post-harvest*				
round	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
< 1 year	5	7.42	1.4	2.06	1.5	3.68	1.1				
12-23	10	2.74	1.4	2.30	1.5	2.06	1.1	Absolute height change	1.9	5.593	0.006
24-35	9	3.13	1.4	2.53	1.5	2.42	1.1	Absolute height change *	7.4	4.505	<0.001
36-48	15	2.05	1.4	2.66	1.5	2.40	1.1	yearly age classes			
48-59	16	1.80	1.4	2.57	1.5	2.44	1.1				
Longitudinal sample 1: Primary-school estimated mean absolute seasonal 4-monthly height (cm) by yearly age classes											
5-5.99	9	1.74	1.0	1.93	0.9	1.84	0.7				
6-6.99	14	1.58	1.0	1.99	0.9	1.47	0.7	Absolute height change	1.8	3.725	0.030
7-7.99	17	1.54	1.0	1.88	0.9	1.22	0.7	Absolute height change *	7.4	0.767	n.s.
8-8.99	16	1.07	1.0	1.74	0.9	1.74	0.7	yearly age classes			
9-9.99	17	1.07	1.0	1.66	0.9	1.47	0.7				
Longitudinal sample 1: Adolescent estimated mean absolute seasonal 4-monthly height (cm) by yearly age classes											
10-10.99	17	1.57	1.0	1.67	0.9	1.62	0.9				
11-11.99	10	1.24	1.0	2.02	0.9	1.70	0.9				
12-12.99	12	1.48	1.0	1.96	0.9	1.57	0.9	Absolute height change	2	0.803	n.s.
13-13.99	5	1.14	1.0	1.61	0.9	0.82	0.9	Absolute height change *	14	0.509	n.s.
14-14.99	8	1.43	1.0	1.01	0.9	1.43	0.9	yearly age classes			
15-15.99	3	0.50	1.0	0.20	0.9	0.06	0.9				
16-16.99	2	0.70	1.0	0.68	0.9	0.02	0.9				
17-17.99	3	0.78	1.0	0.47	0.9	0.35	0.9				

Table 6.6.32 *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute height (cm) changes for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 2: Pre-school estimated mean absolute seasonal 4-monthly height (cm) changes by yearly age classes and gender														
	Harvest						*Post-harvest*							
	Male			**Female**			**Male**		**Female**					
	n	**Mean**	**SD**	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	12	6.13	1.8	14	4.53	1.8	3.2	1.5	4.39	1.5	Absolute height change	1	3.168	n.s.
12-23	16	2.20	1.8	22	2.30	1.8	2.77	1.5	2.87	1.5	Absolute height change * yearly age class	4	2.790	0.028
24-35	14	3.09	1.8	13	2.08	1.8	1.92	1.5	2.14	1.5	Absolute height change * gender	1	5.111	0.025
36-48	20	2.02	1.8	19	2.57	1.8	2.45	1.5	2.40	1.5	Absolute height change * yearly age classes	4	1.789	n.s.
48-59	20	2.98	1.8	30	2.06	1.8	2.28	1.5	2.20	1.5	* gender			
Longitudinal sample 2: Primary school estimated mean absolute seasonal 4-monthly height (cm) changes by yearly age classes and gender														
5-5.99	21	2.00	0.9	20	1.80	0.9	1.56	0.8	2.20	0.8	Absolute height change	1	2.966	n.s.
6-6.99	17	1.75	0.9	18	2.08	0.9	1.34	0.8	1.70	0.8	Absolute height change * yearly age class	4	0.849	n.s.
7-7.99	30	1.63	0.9	29	1.68	0.9	1.43	0.8	1.37	0.8	Absolute height change * gender	4	0.205	n.s.
8-8.99	19	1.62	0.9	35	1.68	0.9	1.52	0.8	1.50	0.8	Absolute height change * yearly age classes	1	1.182	n.s.
9-9.99	36	1.30	0.9	26	1.62	0.9	1.50	0.8	1.54	0.8	* gender			
Longitudinal sample 2: Adolescent estimated mean absolute seasonal 4-monthly height (cm) changes by yearly age classes and gender														
10-10.99	27	1.59	0.9	41	1.45	0.9	1.23	0.8	1.50	0.8				
11-11.99	22	1.75	0.9	27	1.86	0.9	1.31	0.8	1.70	0.8	Absolute height change	1	8.107	0.005
12-12.99	26	1.19	0.9	29	1.68	0.9	1.35	0.8	1.57	0.8	Absolute height change * yearly age class	7	0.853	n.s.
13-13.99	19	1.69	0.9	17	1.79	0.9	1.62	0.8	1.19	0.8	Absolute height change * gender	1	1.115	n.s.
14-14.99	21	1.41	0.9	13	1.67	0.9	1.55	0.8	0.93	0.8	Absolute height change * yearly age classes	7	1.467	n.s.
15-15.99	13	1.82	0.9	15	0.82	0.9	1.62	0.8	0.36	0.8	* gender			
16-16.99	13	1.75	0.9	8	0.74	0.9	1.09	0.8	0.37	0.8				
17-17.99	7	0.93	0.9	5	0.40	0.9	1.24	0.8	0.34	0.8				

Table 6.6.33: *Repeat measures ANOVA within-subject effect of yearly age classes and gender on* ***harvest*** *and* ***post-harvest*** *seasonal 4-monthly estimated mean absolute height (cm) changes for longitudinal sample 2: by pre-school (n=180), primary school-aged (n=251) and adolescents (n=303) population*

Longitudinal sample 1: Pre-school estimated mean absolute (cm) and relative (%) annual height velocity by yearly age classes													
	Annual absolute (kg) height velocity							Annual relative (%) height velocity					
	n	Mean	SD	Main effect	df	F	*p*	Mean	SD	Main effect	df	F	*p*
0-11	5	13.2	1.5					21.6	2.3				
12-23	10	7.1	1.5					9.5	2.3				
24-35	9	8.1	1.5	Yearly age classes	4	19.853	<0.001	9.5	2.3	Yearly age classes	4	41.638	<0.001
36-48	15	7.1	1.5					7.7	2.3				
48-59	16	6.8	1.5					6.9	2.3				
Longitudinal sample 1: Primary school-aged population estimated mean absolute (cm) and relative (%) annual height velocity by yearly age classes													
5-5.99	9	5.5	1.1					5.3	0.9				
6-6.99	14	5.0	1.1					4.5	0.9				
7-7.99	17	4.6	1.1	Yearly age classes	4	2.678	0.039	3.9	0.9	Yearly age classes	4	8.319	<0.001
8-8.99	16	4.6	1.1					3.7	0.9				
9-9.99	17	4.2	1.1					3.2	0.9				
Longitudinal sample 1: Adolescent population estimated mean absolute (cm) and relative (%) annual height velocity by yearly age classes													
10-10.99	17	4.9	1.5					3.6	1.1				
11-11.99	10	5.0	1.5					3.5	1.1				
12-12.99	12	5.0	1.5					3.6	1.1				
13-13.99	5	3.6	1.5	Yearly age classes	7	6.181	<0.001	2.5	1.1	Yearly age classes	7	7.071	<0.001
14-14.99	8	4.0	1.5					2.7	1.1				
15-15.99	3	0.7	1.5					0.7	1.1				
16-16.99	2	1.4	1.5					0.8	1.1				
17-17.99	3	1.6	1.5					1.0	1.1				

Table 6.6.34: *One-way ANOVA within-subject effect of yearly age classes on estimated mean annual absolute height (cm) and relative height (%) velocities for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Observed and derived 4-monthly seasonal weight (kg) increments for pre-school children							
	Buhera		**NCHS Median**		**df**	**t**	***p***
Season	**Mean**	**SD**	**Mean**	**SD**			
Pre-harvest	0.87	0.7	0.77	0.34	54	1.219	n.s.
Harvest	0.98	0.7	0.72	0.2	54	2.604	0.012
Post-harvest	0.27	0.6	0.67	0.1	54	5.070	<0.001
Annual	2.12	0.8	2.15	0.6	54	0.166	n.s.
Longitudinal sample 1: Observed and derived 4-monthly seasonal weight (kg) increments for primary-school children							
Pre-harvest	1.17	0.7	0.97	0.2	72	2.381	0.020
Harvest	0.88	0.6	1.04	0.3	72	1.985	0.051
Post-harvest	0.16	0.7	1.07	0.2	72	10.734	<0.001
Annual	2.22	0.9	3.08	0.7	72	6.681	<0.001
Longitudinal sample 1: Observed and derived 4-monthly seasonal weight (kg) increments for adolescents							
Pre-harvest	1.63	1.1	1.46	0.4	59	0.967	n.s.
Harvest	1.20	1.2	1.45	0.5	59	1.434	n.s.
Post-harvest	0.65	1.4	1.43	0.5	59	4.151	<0.001
Annual	3.48	1.8	4.32	1.4	59	2.571	0.013

Table 6.6.35: *Paired t-test comparing observed 4-monthly seasonal weight (kg) increments with 4-monthly weight (kg) increments derived from the NCHS for comparable demographic profile matched by month of age and gender for the three discrete periods of childhood*

Longitudinal sample 1: Observed and derived 4-monthly seasonal height (cm) increments for pre-school children							
	Buhera		**NCHS Median**		**df**	**t**	***p***
Season	**Mean**	**SD**	**Mean**	**SD**			
Pre-harvest	2.77	2.1	3.16	1.3	54	1.880	n.s.
Harvest	2.49	1.4	2.89	0.9	54	1.720	n.s.
Post-harvest	2.47	1.2	2.70	0.7	54	1.410	n.s.
Annual	7.73	2.3	8.75	2.8	54	3.659	0.001
Longitudinal sample 1: Observed and derived 4-monthly seasonal height (cm) increments for primary school children							
Pre-harvest	1.36	1.0	1.91	0.1	72	4.903	<0.001
Harvest	1.82	0.9	1.90	0.1	72	0.777	n.s.
Post-harvest	1.51	0.7	1.92	0.1	72	4.582	<0.001
Annual	4.70	1.1	5.73	0.4	72	7.875	<0.001
Longitudinal sample 1: Observed and derived 4-monthly seasonal height (cm) increments for adolescents							
Pre-harvest	1.32	1.0	1.78	0.7	59	3.201	0.002
Harvest	1.54	1.0	1.71	0.8	59	1.483	n.s.
Post-harvest	1.33	1.0	1.64	0.8	59	2.529	0.014
Annual	4.19	1.9	5.11	2.3	59	3.700	<0.001

Table 6.6.36: *Paired t-test comparing observed 4-monthly seasonal height (cm) increments with 4-monthly height (cm) increments derived from the NCHS for comparable demographic profile matched by month of age and gender for the three discrete periods of childhood*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal MUAC (cm) increments by age group and gender											
		Pre-harvest		*Harvest*		*Post-harvest*		**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-school											
Male	24	0.017	0.7	0.292	0.6	0.033	0.6				
Females	23	-0.061	0.7	0.322	0.6	0.591	0.6				
All	47	-0.022	0.7	0.307	0.6	0.312	0.6				
Primary school								Absolute MUAC change	2	12.011	<0.001
Males	30	-0.150	0.7	0.250	0.6	0.163	0.6	Absolute MUAC change * age group	4	1.490	n.s.
Females	39	-0.046	0.7	0.387	0.6	0.028	0.6	Absolute MUAC change * gender	2	0.513	n.s.
All	69	-0.098	0.7	0.319	0.6	0.096	0.6	Absolute MUAC change * age group * gender	4	1.494	n.s.
Adolescent											
Males	21	-0.138	0.7	0.162	0.6	0.348	0.6				
Females	23	-0.087	0.6	0.206	0.5	0.487	0.5				
All	53	-0.113	0.7	0.184	0.6	0.418	0.6				
Whole child sample											
Males	75	-0.090	0.7	0.235	0.6	0.181	0.6				
Females	94	-0.065	0.7	0.305	0.6	0.369	0.6				
All	169	-0.078	0.7	0.270	0.6	0.275	0.7				

Table 6.6.37: *Repeat measures ANCOVA within-subject effect of age group and gender on seasonal MUAC increments for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole population estimated mean absolute annual MUAC (cm) velocity by gender												
	Annual absolute MUAC (cm) velocity						**Annual relative MUAC (%) velocity**					
	Mean	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
Males n=75	0.31	0.8	Absolute annual MUAC increment* age	1	0.215	n.s.	1.95	4.9	Absolute annual relative MUAC increment* age	1	3.235	n.s.
Female n=94	0.57	0.8	Absolute annual MUAC increment* age²	1	9.508	0.002	3.68	4.9	Absolute annual relative MUAC increment* age²	1	9.317	0.003
Total Pop. n=169	0.44	0.8	Absolute annual MUAC increment* gender	1	4.629	0.033	2.82	5.0	Absolute annual relative MUAC increment* gender	1	5.097	0.025

Table 6.6.38: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) MUAC velocity for longitudinal sample 1 of adolescents (n=188)*

Longitudinal sample 1: Whole child sample estimated mean absolute annual MUAC (cm) velocity by age group and gender							
	Annual			Main effect	df	F	*p*
	n	Mean	SD				
Pre-school							
Male	24	0.34	0.8				
Females	23	0.85	0.8				
All	47	0.60	0.8				
Primary school							
Males	30	0.26	0.8	Absolute annual MUAC increment* age group	2	1.758	n.s.
Females	39	0.37	0.8	Absolute annual MUAC increment* gender	1	4.374	0.038
All	69	0.32	0.8	Absolute annual MUAC increment* age group*gender	2	0.896	n.s.
Adolescent							
Males	21	0.37	0.8				
Females	23	0.61	0.7				
All	53	0.49	0.8				
Whole sample							
Males	75	0.33	0.8				
Females	94	0.61	0.8				
All	169	0.47	0.8				

Table 6.6.39: *Repeat measures ANCOVA within-subject effect of gender and age group on annual absolute MUAC increments cm) for the whole child longitudinal sample 1 (n=169)*

Longitudinal sample 1: Whole child sample estimated mean relative annual MUAC (%) velocity by age group and gender							
	Annual			Main effect	df	F	*p*
	n	Mean	SD				
Pre-school							
Male	24	2.40	5.0				
Females	23	6.28	5.0				
All	47	4.34	5.0				
Primary school							
Males	30	1.76	5.0				
Females	39	2.45	5.0	Relative annual MUAC increment* age group	2	2.633	n.s.
All	69	2.11	5.1	Relative annual MUAC increment* gender	1	5.126	0.025
Adolescent				Relative annual MUAC increment* age group *gender	2	1.482	n.s.
Males	21	1.92	5.0				
Females	23	3.18	4.3				
All	53	2.55	5.1				
Whole sample							
Males	75	2.03	5.1				
Females	94	3.97	5.1				
All	169	3.00	5.1				

Table 6.6.40: *Repeat measures ANCOVA within-subject effect of gender and age group on relative annual MUAC (%) increments for the whole child longitudinal sample 1 (n=169)*

Longitudinal sample 1: Pre-school estimated mean MUAC (cm) by gender and survey round										
Survey	Total Pop. (n=47)		Male (n=24)		Female (n=23)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94	14.6	1.1	15.0	1.1	14.3	1.1	MUAC	2.9	5.124	0.002
Mar-95	14.6	1.3	15.0	1.3	14.2	1.3	MUAC * age	2.9	1.781	n.s.
Jul-95	14.9	1.1	15.3	1.2	14.5	1.2	MUAC * gender	2.9	2.278	n.s.
Nov-95	15.2	1.2	15.4	1.2	15.1	1.2				

Table 6.6.41: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal MUAC measurements(cm) for longitudinal sample 1 of pre-school children (n=47)*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal MUAC (cm) changes by gender										
Survey	Total Pop. (n=47)		Male (n=24)		Female (n=23)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	-0.02	0.9	0.07	0.9	-0.12	0.9	Absolute MUAC change	1.9	0.237	n.s.
Harvest	0.31	0.7	0.28	0.7	0.33	0.7	Absolute MUAC change* age	1.9	1.013	n.s.
Post-harvest	0.31	0.6	0.05	0.6	0.57	0.6	Absolute MUAC change* gender	1.9	2.067	n.s.
Longitudinal sample 1: Pre-school estimated mean relative (%) seasonal MUAC changes by gender										
Pre-harvest	-0.07	6.1	0.57	6.2	-0.74	6.2	Relative MUAC change	1.9	0.215	n.s.
Harvest	2.29	4.8	2.09	4.8	2.50	4.8	Relative MUAC change* age	1.9	1.058	n.s.
Post-harvest	2.24	4.3	0.34	4.3	4.2	4.3	Relative MUAC change* gender	1.9	2.272	n.s.

Table 6.6.42: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute MUAC increments (cm) and relative MUAC (%) increments for longitudinal sample 1 of pre-school children (n=47)*

Longitudinal sample 1: Pre-school estimated mean absolute annual MUAC (cm) velocity by gender										
Survey	Total Pop. (n=47)		Male (n=24)		Female (n=23)		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Annual	0.60	0.9	0.41	0.9	0.78	0.9	Absolute annual MUAC * age	1	5.060	0.030
							Absolute annual MUAC * gender	1	1.799	n.s.
Longitudinal sample 1: Pre-school estimated mean relative (%) annual MUAC velocity by gender										
Annual	4.33	6.4	2.89	6.5	5.77	6.5	Relative annual MUAC * age	1	5.985	0.018
							Relative annual MUAC * gender	1	2.217	n.s.

Table 6.6.43: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) MUAC velocities for longitudinal sample 1 of pre-school children (n=47).*

Longitudinal sample 1: Primary school-aged estimated mean MUAC (cm) by gender and survey round										
Survey round	Total Pop. n=69		Male n=30		Female n=39		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	16.0	1.2	16.1	1.2	15.9	1.2	MUAC	2.9	0.515	n.s.
Mar-95	15.9	1.2	15.9	1.2	15.9	1.2	MUAC * age	2.9	0.260	n.s.
Jul-95	16.2	1.3	16.2	1.3	16.3	1.3	MUAC * gender	2.9	0.774	n.s.
Nov-95	16.3	1.2	16.3	1.2	16.3	1.2				

Table 6.6.44: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal MUAC (cm) increments for longitudinal sample 1 of primary school-aged children (n=69)*

Longitudinal sample 1: Primary school-aged estimated mean absolute seasonal MUAC (cm) changes by gender										
Survey round	Total Pop. n=69		Male n=30		Female n=39		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	-0.10	0.6	-0.15	0.6	-0.04	0.6	Absolute MUAC change	2	0.341	n.s.
Harvest	0.32	0.6	0.25	0.6	0.39	0.6	Absolute MUAC change* age	2	0.504	n.s.
Post-harvest	0.10	0.6	0.16	0.6	0.03	0.6	Absolute MUAC change* gender	2	0.775	n.s.
Longitudinal sample 1: Primary school-aged estimated mean relative seasonal MUAC (%) changes by gender										
Pre-harvest	-0.51	4.0	-0.80	4.0	-0.22	4.0	Relative MUAC change	2	0.312	n.s.
Harvest	2.00	3.5	1.58	3.5	2.42	3.5	Relative MUAC change* age	2	0.345	n.s.
Post-harvest	0.72	3.9	1.06	3.9	0.39	3.9	Relative MUAC change* gender	2	0.601	n.s.

Table 6.6.45: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute MUAC (cm) and relative MUAC (%) increments for longitudinal sample 1 of primary school-aged children (n=69)*

Longitudinal sample 1: Primary school-aged estimated mean absolute annual MUAC (cm) velocity by gender										
Survey round	Total Pop. n=69		Male n=30		Female n=39		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.32	0.7	0.26	0.7	0.37	0.7	Absolute annual MUAC * age	1	0.036	n.s.
							Absolute annual MUAC * gender	1	0.399	n.s.
Longitudinal sample 1: Primary school-aged estimated mean relative absolute annual MUAC (%) velocity by gender										
Annual	2.11	4.5	1.76	4.5	2.46	4.5	Relative annual MUAC * age	1	0.214	n.s.
							Relative annual MUAC * gender	1	0.415	n.s.

Table 6.6.46: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) MUAC velocities for longitudinal sample 1 of primary school-aged children (n=69).*

Longitudinal sample 1: Adolescent estimated mean MUAC (cm) by gender and survey round										
Survey round	**Total Pop.n=53**		**Male n=21**		**Female n=32**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94	19.5	1.8	18.9	1.8	20.1	1.8	MUAC	3	2.322	n.s.
Mar-95	19.4	1.9	18.7	1.9	20.0	1.8	MUAC * age	3	2.195	n.s.
Jul-95	19.6	1.6	18.9	1.6	20.3	1.6	MUAC * gender	3	0.824	n.s.
Nov-95	20.0	1.7	19.2	1.7	20.7	1.7				

Table 6.6.47: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal MUAC increments (cm) for longitudinal sample 1 of adolescents (n=53)*

Longitudinal sample 1: Adolescent estimated mean absolute seasonal MUAC (cm) changes by gender										
Survey round	**Total Pop. n=53**		**Male n=21**		**Female n=32**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	-0.123	0.6	-0.195	0.6	-0.050	0.6	Absolute MUAC change	2	3.027	0.053
Harvest	0.183	0.6	0.156	0.6	0.210	0.6	Absolute MUAC change* age	2	1.807	n.s.
Post-harvest	0.420	0.7	0.364	0.7	0.477	0.7	Absolute MUAC change* gender	2	0.051	n.s.
Longitudinal sample 1: Adolescent estimated mean relative (%) seasonal MUAC changes by gender										
Pre-harvest	-0.70	3.2	-1.048	3.2	-0.348	3.2	Relative MUAC change	2	3.248	0.043
Harvest	1.08	3.2	0.951	3.2	1.198	3.2	Relative MUAC change* age	2	1.891	n.s.
Post-harvest	2.22	3.5	1.921	3.5	2.521	3.5	Relative MUAC change* gender	2	0.051	n.s.

Table 6.6.48: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute MUAC increments (cm) and relative MUAC (%) increments for longitudinal sample 1 of adolescents (n=53)*

Longitudinal sample 1: Adolescent estimated mean absolute annual MUAC (cm) velocity by gender										
Survey round	**Total Pop.n=53**		**Male n=21**		**Female n=32**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	0.481	0.8	0.325	0.8	0.637	0.8	Absolute annual MUAC * age	1	1.610	n.s.
							Absolute annual MUAC * gender	1	1.947	n.s.
Longitudinal sample 1: Adolescent estimated mean relative (%) annual MUAC velocity by gender										
Annual	2.519	4.1	1.735	4.1	3.304	4.1	Relative annual MUAC * age	1	0.816	n.s.
							Relative annual MUAC * gender	1	1.832	n.s.

Table 6.6.49: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute (cm) and relative (%) MUAC velocities for longitudinal sample 1 of adolescents (n=53)*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal changes in BMI by age group and gender											
		Pre-harvest		*Harvest*		*Post-harvest*		Main effect	df	F	*p*
	n	Mean	SD	Mean	SD	Mean	SD				
Pre-school											
Male	24	0.56		-0.09		-0.41					
Females	23	-0.02		0.67		-0.59					
All	47	0.27		0.29		-0.50					
Primary school								Absolute BMI change	2	41.526	<0.001
Males	30	0.53		0.17		-0.33		Absolute BMI change * age group	4	2.751	0.028
Females	39	0.42		0.17		-0.22		Absolute BMI change * gender	2	6.069	0.003
All	69	0.47		0.17		-0.28		Absolute BMI change * age group * gender	4	4.108	0.003
Adolescent											
Males	21	0.47		0.13		-0.07					
Females	23	0.47		0.26		0.07					
All	53	0.47		0.20		0.01					
Whole child sample											
Males	75	0.52		0.07		-0.27					
Females	94	0.29		0.37		-0.25					
All	169	0.41		0.22		-0.26					

Table 6.6.52: *Repeat measures ANCOVA within-subject effect of age group and gender on seasonal changes in BMI for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child population estimated mean absolute annual change in BMI by gender										
Survey round	Total Pop. n=188		Male n=81		Female n=107		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.37	0.8	0.31	0.8	0.44	0.8	Absolute annual change in BMI* age	1	20.246	<0.001
							Absolute annual change in BMI* age²	1	4.391	0.037
							Absolute annual change in BMI * gender	1	1.037	n.s.

Table 6.6.53: *One-way ANCOVA between-subject effect of gender after controlling for age on annual change in BMI for whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean absolute annual change in BMI by age group and gender							
	Annual			Main effect	df	F	*p*
	n	Mean	SD				
Pre-school							
Male	24	0.058	0.8				
Females	31	0.059	0.8				
All	55	0.06	0.8				
Primary school							
Males	33	0.37	0.8	Absolute annual change in BMI* age group	2	8.625	<0.001
Females	40	0.37	0.8	Absolute annual change in BMI* gender	1	0.525	n.s.
All	73	0.37	0.8	Absolute annual change in BMI * age group *gender	2	0.584	n.s.
Adolescent							
Males	24	0.53	0.8				
Females	36	0.81	0.8				
All	60	0.67	0.8				
Whole sample							
Males	81	0.32	0.8				
Females	107	0.41	0.8				
All	188	0.37	0.8				

Table 6.6.54: *Repeat measures ANCOVA within-subject effect of gender and age group on annual change in BMI for the whole child longitudinal sample 1 (n=169)*

Longitudinal sample 1: Pre-school estimated mean BMI by gender and survey round										
Survey round	Total Pop. n=55		Male n=24		Female n=31		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	15.3	1.3	15.6	1.3	14.9	1.3	BMI	2.5	4.062	0.013
Mar-95	15.6	1.5	16.3	1.5	14.8	1.5	BMI * age	2.5	1.418	n.s.
Jul-95	15.9	1.4	16.2	1.4	15.5	1.4	BMI * gender	2.5	3.466	0.025
Nov-95	15.4	1.2	15.8	1.3	14.9	1.3				

Table 6.6.55: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal BMI measurements(cm) for longitudinal sample 1 of pre-school children (n=55)*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal BMI changes by gender										
Survey round	Total Pop. n=55		Male n=24		Female n=31		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	0.28	0.9	0.64	0.9	-0.09	0.9	Absolute BMI change	2	5.421	0.006
Harvest	0.29	0.8	-1.0	0.8	0.68	0.8	Absolute BMI change* age	2	1.691	n.s.
Post-harvest	-0.50	0.9	-0.43	0.9	-0.58	0.9	Absolute BMI change* gender	2	8.405	<0.001

Table 6.6.56: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute BMI increments for longitudinal sample 1 of pre-school children (n=47)*

Longitudinal sample 1: Pre-school estimated mean absolute change in annual BMI by gender										
Survey round	Total Pop. n=55		Male n=24		Female n=31		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.06	1.1	0.04	1.1	0.08	1.1	Absolute annual BMI increment* age	1	1.208	n.s.
							Absolute annual BMI increment* age^2	1	0.032	n.s.
							Absolute annual BMI increment* age^3	1	9.147	0.004
							Absolute annual BMI increment* gender	1	0.015	n.s.

Table 6.6.57: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute BMI increment for longitudinal sample 1 of pre-school children (n=55).*

Longitudinal sample 1: Primary school estimated mean BMI by gender and survey round										
Survey	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Nov-94	14.3	1.1	14.3	1.1	14.3	1.1	BMI	3	3.322	0.021
Mar-95	14.8	1.2	14.9	1.2	14.7	1.2	BMI * age	3	1.399	n.s.
Jul-95	15.0	1.1	15.0	1.1	14.9	1.1	BMI * gender	3	0.537	n.s.
Nov-95	14.7	1.1	14.7	1.1	14.7	1.1				

Table 6.6.58: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal BMI measurements(cm) for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Primary school estimated mean absolute seasonal BMI changes by gender										
Survey	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	0.47	0.6	0.53	0.6	0.42	0.6	Absolute BMI change	2	4.296	0.015
Harvest	0.17	0.4	0.17	0.4	0.17	0.4	Absolute BMI change* age	2	2.763	n.s.
Post-harvest	-0.28	0.5	-0.33	0.4	-0.22	0.4	Absolute BMI change* gender	2	0.653	n.s.

Table 6.6.59: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute BMI increments for longitudinal sample 1 of primary school-aged children (n=73)*

Longitudinal sample 1: Primary school estimated mean absolute change in annual BMI by gender										
Survey	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
round	Mean	SD	Mean	SD	Mean	SD				
Annual	0.37	0.5	0.368	0.5	0.366	0.5	Absolute annual BMI increment* age	1	0.103	n.s.
							Absolute annual height increment* gender	1	0.000	n.s.

Table 6.6.60: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute BMI increment for longitudinal sample 1 of primary school children (n=73).*

Longitudinal sample 1: Adolescent estimated mean BMI by gender and survey round										
Survey round	**Total Pop. n=60**		**Male n=24**		**Female n=36**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94	16.1	1.4	15.6	1.4	16.7	1.4	BMI	3	3.854	0.011
Mar-95	16.6	1.5	16.0	1.5	17.2	1.5	BMI * age	3	7.835	<0.001
Jul-95	16.8	1.5	16.1	1.5	17.5	1.5	BMI * gender	3	3.285	0.022
Nov-95	16.8	1.5	16.0	1.5	17.6	1.5				

Table 6.6.61: *Repeat measures ANCOVA within-subject effect of gender after controlling for age on seasonal BMI measurements(cm) for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Adolescent estimated mean absolute seasonal BMI changes by gender										
Survey round	**Total Pop. n=60**		**Male n=24**		**Female n=36**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	0.46	0.5	0.41	0.5	0.52	0.5	Absolute BMI change	2	0.078	n.s.
Harvest	0.19	0.6	0.09	0.6	0.29	0.6	Absolute BMI change* age	2	0.479	n.s.
Post-harvest	-0.002	0.7	-0.09	0.7	0.08	0.7	Absolute BMI change* gender	2	0.086	n.s.

Table 6.6.62: *Repeat measures ANCOVA within-subject effects of gender after controlling for age on seasonal absolute BMI increments for longitudinal sample 1 of adolescents (n=60)*

Longitudinal sample 1: Adolescent estimated mean absolute change in annual BMI by gender										
Survey round	**Total Pop. n=60**		**Male n=24**		**Female n=36**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	0.65	0.7	0.41	0.7	0.90	0.7	Absolute annual BMI increment* age	1	11.753	0.001
							Absolute annual height increment* gender	1	6.640	0.013

Table 6.6.63: *One-way ANCOVA between-subject effect of gender after controlling for age on annual absolute BMI increment for longitudinal sample 1 of adolescents (n=60).*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal HAZ increments by age group, gender and season											
		Pre-harvest		*Harvest*		*Post-harvest*		**Main effect**	**df**	**F**	***p***
	n	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-school											
Male	24	-0.11	0.3	0.04	0.3	0.019	0.2				
Females	31	0.13	0.3	-0.13	0.3	0.025	0.2				
All	55	0.01	0.3	-0.04	0.3	0.02	0.2				
Primary school								Absolute change HAZ	1.7	0.093	n.s.
Males	33	-0.07	0.3	0.01	0.3	-0.03	0.2	Absolute change HAZ * age group	3.4	1.024	n.s.
Females	40	-0.03	0.3	0.02	0.3	-0.09	0.2	Absolute change HAZ *gender	1.7	3.571	0.036
All	73	-0.05	0.3	0.01	0.3	-0.05	0.2	Absolute change HAZ * age group * gender	3.4	2.201	n.s.
Adolescent											
Males	24	-0.06	0.3	-0.03	0.3	-0.06	0.2				
Females	36	-0.03	0.3	-0.01	0.3	-0.06	0.2				
All	60	-0.04	0.3	-0.02	0.3	-0.06	0.2				
Whole child sample											
Males	81	-0.08	0.3	0.007	0.3	-0.02	0.2				
Females	107	0.03	0.3	-0.04	0.3	-0.04	0.2				
All	188	-0.004	0.3	-0.03	0.3	-0.04	0.2				

Table 6.7.1: *Repeat measures ANCOVA within-subject effect of age group and gender on absolute seasonal changes in HAZ for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child population estimated mean absolute annual HAZ change by gender										
Survey round	**Total Pop. n=188**		**Male n=81**		**Female n=107**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	-0.076	0.3	-0.095	0.3	-0.057	0.3	Annual HAZ change * age	1	0.446	n.s.
							Annual HAZ * gender	1	0.736	n.s.

Table 6.7.2: *One-way ANCOVA between-subject effect of gender after controlling for age on annual HAZ change for whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal BMIZ changes by gender, age group and season											
		Pre-harvest		*Harvest*		*Post-harvest*		Main effect	df	F	*p*
	n	Mean	SD	Mean	SD	Mean	SD				
Pre-school											
Male	21	0.43	0.5	0.03	0.5	-0.32	0.4				
Females	19	-0.11	0.5	0.67	0.5	-0.46	0.4				
All	40	0.16	0.6	0.35	0.5	-0.39	0.4				
Primary school											
Males	33	0.50	0.5	0.11	0.5	-0.36	0.4				
Females	40	0.25	0.6	0.09	0.5	-0.23	0.4	Absolute change BMIZ	2	36.196	<0.001
All	73	0.37	0.6	0.10	0.5	-0.30	0.4	Absolute change BMIZ * age group	4	5.215	<0.001
Adolescent								Absolute change BMIZ *gender	2	8.152	<0.001
Males	24	0.18	0.5	-0.02	0.5	-0.15	0.4	Absolute change BMIZ * age group* gender	4	3.755	0.005
Females	36	0.14	0.5	0.04	0.5	-0.07	0.4				
All	60	0.16	0.6	0.01	0.5	-0.11	0.4				
Whole child sample											
Males	78	0.37	0.6	0.04	0.5	-0.28	0.4				
Females	95	0.09	0.6	0.27	0.5	-0.25	0.4				
All	173	0.23	0.6	0.15	0.5	-0.27	0.4				

Table 6.7.3: *Repeat measures ANCOVA within-subject effect of gender and age group on absolute seasonal changes in BMIZ for the whole child longitudinal sample 1 (n=1)*

Longitudinal sample 1: Whole child population estimated mean absolute annual BMIZ change by gender										
Survey round	Total Pop. (n=173)		Male (n=78)		Female (=95)		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.13	0.6	0.14	0.5	0.11	0.5	Annual BMIZ change * age	1	0.185	n.s.
							Annual BMIZ * gender	1	0.133	n.s.

Table 6.7.4: *One-way ANCOVA between-subject effect of gender after controlling for age on annual HAZ change for whole child longitudinal sample 1 (n=173)*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal WHZ changes by gender, age group and season											
		Pre-harvest		*Harvest*		*Post-harvest*		Main effect	df	F	*p*
	n	Mean	SD	Mean	SD	Mean	SD				
Pre-school											
Male	24	0.45	0.5	0.03	0.4	-0.18	0.5				
Females	31	-0.05	0.5	0.53	0.4	-0.32	0.5				
All	55	0.20	0.5	0.28	0.4	-0.25	0.5				
Primary school								Absolute change WHZ	2	33.542	<0.001
Males	33	0.37	0.5	0.09	0.4	-0.28	0.4	Absolute change WHZ * age group	2	2.953	0.054
Females	37	0.26	0.5	0.09	0.4	-0.17	0.5	Absolute change WHZ *gender	2	8.831	<0.001
All	70	0.32	0.5	0.09	0.4	-0.23	0.5	Absolute change WHZ * age group * gender	2	6.720	0.001
Whole child sample											
Males	57	0.41	0.5	0.06	0.4	-0.23	0.5				
Females	68	0.11	0.5	0.31	0.4	-0.25	0.5				
All	125	0.26	0.5	0.19	0.4	-0.24	0.5				

Table 6.7.5: *Repeat measures ANCOVA within-subject effect of gender and age group on absolute seasonal changes in WHZ for the whole child sample aged <10 years longitudinal sample 1 (n=125)*

Longitudinal sample 1: Whole child population aged <10 years estimated mean absolute annual WHZ change by gender										
Survey round	Total Pop. n=125		Male n=57		Female n=68		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.20	0.7	0.23	0.7	0.17	0.7	Annual WHZ change * age	1	0.295	n.s.
							Annual WHZ * gender	1	0.293	n.s.

Table 6.7.6: *One-way ANCOVA between-subject effect of gender after controlling for age on annual WHZ change for whole child sample aged <10 years longitudinal sample 1 (n=125)*

Longitudinal sample 1: Whole child sample estimated mean absolute seasonal WAZ changes by age group and gender											
		Pre-harvest		*Harvest*		*Post-harvest*		Main effect	df	F	*p*
	n	Mean	SD	Mean	SD	Mean	SD				
Pre-school											
Male	24	0.28	0.3	0.04	0.4	-0.16	0.3				
Females	31	0.17	0.3	0.34	0.4	-0.24	0.3				
All	55	0.19	0.3	0.19	0.4	-0.20	0.3				
Primary school								Absolute change WAZ	1.9	38.910	<0.001
Males	33	0.18	0.3	0.06	0.4	-0.19	0.3	Absolute change WAZ * age group	1.9	1.510	n.s.
Females	40	0.12	0.3	0.05	0.4	-0.18	0.3	Absolute change WAZ *gender	1.9	4.177	0.017
All	73	0.15	0.3	0.06	0.4	-0.18	0.3	Absolute change WAZ * age group * gender	1.9	3.570	0.031
Whole child sample											
Males	57	0.23	0.3	0.05	0.4	-0.18	0.3				
Females	71	0.16	0.3	0.20	0.4	-0.21	0.3				
All	128	0.17	0.3	0.13	0.4	-0.19	0.3				

Table 6.7.7: *Repeat measures ANCOVA within-subject effect of age group and gender on absolute seasonal changes in WAZ for the whole child longitudinal sample 1 (n=128)*

Longitudinal sample 1: Whole child population aged <10 years estimated mean absolute annual WAZ change by gender										
Survey round	Total Pop. n=128		Male n=57		Female n=71		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	0.095	0.5	0.10	0.5	0.086	0.5	Annual WAZ change * age	1	3.455	n.s.
							Annual WAZ * gender	1	0.045	n.s.

Table 6.7.8: *One-way ANCOVA between-subject effect of gender after controlling for age on annual WAZ change for whole child longitudinal sample 1 aged <10 years (n=125)*

Longitudinal sample 1: Whole child sample estimated mean absolute annual HAZ change by age group and gender							
	Annual			Main effect	df	F	*p*
	n	Mean	SD				
Pre-school							
Male	24	-0.054	0.3				
Females	31	0.030	0.3				
All	55	-0.012	0.3				
Primary school				Annual HAZ *age group	2	2.050	n.s.
Males	33	-0.090	0.3	Annual HAZ * gender	1	0.849	n.s.
Females	40	-0.093	0.3	Annual HAZ * age group * gender	2	0.349	n.s.
All	73	-0.092	0.3				
Adolescent							
Males	24	-0.15	0.3				
Females	36	-0.092	0.3				
All	60	-0.12	0.3				
Whole child sample							
Males	81	-0.097	0.3				
Females	107	-0.052	0.3				
All	188	-0.074	0.3				

Table 6.7.9: *One-way ANCOVA within-subject effect of age group and gender on annual HAZ change for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Whole child sample aged 2-17.99 years estimated mean absolute annual BMIZ change by age group and gender							
	Annual			Main effect	df	F	*p*
	n	Mean	SD				
Pre-school							
Male	21	0.14	0.5				
Females	19	0.10	0.5				
All	40	0.12	0.5				
Primary school				Annual BMIZ * age group	1	0.622	n.s.
Males	33	0.24	0.5	Annual BMIZ * gender	2	0.112	n.s.
Females	40	0.11	0.5	Annual BMIZ * age group * gender	1	0.747	n.s.
All	73	0.18	0.5				
Adolescent							
Males	24	0.004	0.5				
Females	36	0.11	0.5				
All	60	0.06	0.6				
Whole child sample							
Males	78	0.13	0.6				
Females	95	0.11	0.6				
All	173	0.12	0.6				

Table 6.7.10: *One-way ANCOVA within-subject effect of age group and gender on annual BMIZ change for the whole child longitudinal sample 1 (n=173)*

Longitudinal sample 1: Whole child sample aged (<10 years) estimated mean absolute annual WHZ change by age group and gender							
	Annual			Main effect	df	F	*p*
	n	**Mean**	**SD**				
Pre-school							
Male	24	0.30	0.7				
Females	31	0.16	0.7				
All	55	0.23	0.7				
Primary school				Annual WHZ * age group	1	0.112	n.s.
Males	33	0.18	0.7	Annual WHZ * gender	1	0.245	n.s.
Females	37	0.18	0.7	Annual WHZ * age group * gender	1	0.316	n.s.
All	70	0.18	0.7				
Whole child sample							
Males	57	0.24	0.7				
Females	68	0.17	0.7				
All	125	0.21	0.7				

Table 6.7.11: *One-way ANCOVA within-subject effect of age group and gender on annual WHZ change for the whole child longitudinal sample 1 (n=)*

Longitudinal sample 1: Whole child sample aged (<10 years) estimated mean absolute annual WAZ change by age group and gender							
	Annual			Main effect	df	F	*p*
	n	**Mean**	**SD**				
Pre-school							
Male	24	0.16	0.5				
Females	31	0.21	0.5				
All	55	0.19	0.5				
Primary school				Annual WAZ * age group	1	3.842	0.052
Males	33	0.05	0.5	Annual WAZ * gender	1	0.012	n.s.
Females	40	-0.002	0.5	Annual WAZ * age group * gender	1	0.385	n.s.
All	73	0.03	0.5				
Whole child sample							
Males	57	0.11	0.5				
Females	71	0.10	0.5				
All	128	0.11	0.5				

Table 6.7.12: *One-way ANCOVA within-subject effect of age group and gender on annual WAZ change for the whole child longitudinal sample 1 (n=188)*

Longitudinal sample 1: Pre-school children estimated mean HAZ by gender and survey round										
Survey round	Total Pop. n=55		Male n=24		Female n=31		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Nov-94	-1.49	0.8	-1.41	0.8	-1.58	0.8	HAZ	2.480	12.497	<0.001
Mar-95	-1.48	0.8	-1.50	0.8	-1.46	0.8	HAZ * age	2.480	13.554	<0.001
Jul-95	-1.53	0.8	-1.55	0.8	-1.52	0.8	HAZ * gender	2.480	1.866	n.s.
Nov-95	-1.51	0.8	-1.54	0.8	-1.48	0.8				
Longitudinal sample 1: Pre-school children estimated mean BMIZ by gender and survey round										
	n=40		n=21		n=19					
Nov-94	-0.63	1.2	-0.58	1.2	-0.68	1.2	BMIZ	3.0	1.687	n.s.
Mar-95	-0.47	1.3	-0.15	1.3	-0.80	1.3	BMIZ * age	3.0	0.849	n.s.
Jul-95	-0.12	1.2	-0.12	1.2	-0.13	1.2	BMIZ * gender	3.0	3.232	0.025
Nov-95	-0.51	1.1	-0.45	1.1	-0.58	1.1				
Longitudinal sample 1: Pre-school children estimated mean WHZ by gender and survey round										
	n=55		n=24		n=31					
Nov-94	-0.67	0.9	-0.57	0.8	-0.76	1.0	WHZ	2.24	1.791	n.s.
Mar-95	-0.46	1.0	-0.10	1.0	-0.83	1.0	WHZ * age	2.24	0.153	n.s.
Jul-95	-0.18	0.9	-0.10	0.9	-0.28	0.9	WHZ * gender	2.24	3.052	0.045
Nov-95	-0.43	0.9	-0.27	0.9	-0.60	0.9				
Longitudinal sample 1: Pre-school children estimated mean WAZ by gender and survey round										
Nov-94	-1.46	0.8	-1.31	0.8	-1.61	0.8	WAZ	2.20	4.108	0.016
Mar-95	-1.27	0.9	-0.99	0.9	-1.54	0.9	WAZ * age	2.02	3.881	0.020
Jul-95	-1.08	0.8	-1.00	0.9	-1.15	0.9	WAZ * gender	2.02	3.043	0.047
Nov-95	-1.28	0.8	-1.19	0.8	-1.37	0.8				

Table 6.7.13: Repeat measure ANCOVA within-subject effect of age after controlling for age on seasonal anthropometric indices for longitudinal sample 1 pre-school children (n=55)

Longitudinal sample 1: Pre-school children estimated mean absolute seasonal HAZ by gender and season										
Survey round	Total Pop. =55		Male n=24		Female n=31		Main within subject effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	0.012	0.5	-0.098	0.5	0.123	0.5	Delta HAZ	1.8	5.446	0.008
Harvest	-0.054	0.4	-0.045	0.4	-0.063	0.4	Delta HAZ * age	1.8	5.401	0.008
Post-harvest	0.021	0.3	0.052	0.3	0.036	0.3	Delta HAZ * gender	1.8	0.903	n.s.
Longitudinal sample 1: Pre-school estimated mean absolute seasonal BMIZ by gender and season										
	n=40		**n=21**		**n=19**					
Pre-harvest	0.16	0.7	0.43	0.7	-0.12	0.7	Delta BMIZ	1.9	1.914	n.s.
Harvest	0.35	0.8	0.029	0.8	0.67	0.8	Delta BMIZ * age	1.9	0.977	n.s.
Post-harvest	-0.39	0.6	-0.33	0.6	-0.45	0.6	Delta BMIZ * gender	1.9	5.338	0.008
Longitudinal sample 1: Pre-school estimated mean absolute seasonal WHZ by gender and season										
	n=55		**n=24**		**n=31**					
Pre-harvest	0.20	0.6	0.47	0.7	-0.06	0.7	Delta WHZ	2	2.584	n.s.
Harvest	0.28	0.5	0.02	0.6	0.54	0.6	Delta WHZ * age	2	0.356	n.s.
Post-harvest	-0.25	0.6	-0.19	0.6	-0.32	0.6	Delta WHZ * gender	2	9.128	<0.001
Longitudinal sample 1: Pre-school estimated mean absolute seasonal WAZ by gender and season										
Pre-harvest	0.20	0.4	0.32	0.4	0.076	0.4	Delta WAZ	1.97	7.702	0.001
Harvest	0.19	0.5	-0.01	0.5	0.39	0.5	Delta WAZ * age	1.97	5.114	0.008
Post-harvest	-0.20	0.4	-0.19	0.4	-0.22	0.4	Delta WAZ * gender	1.97	6.283	0.003

Table 6.7.14: Repeat measure ANCOVA within-subject effect of age after controlling for age on 4-monthly seasonal changes in anthropometric indices for longitudinal sample 1 pre-school children (n=55)

Longitudinal sample 1: Pre-school population estimated mean annual HAZ change (n=55)					
	Mean	SD	df	t	*p*
Nov-94	-1.50	0.8	54	0.115	n.s.
Nov-95	-1.51	0.8			
Longitudinal sample 1: Pre-school population estimated mean annual BMIZ change (n=40)					
Nov-94	-0.63	1.1	39	1.813	n.s.
Nov-95	-0.51	1.1			
Longitudinal sample 1: Pre-school population estimated mean annual WHZ change (n=55)					
Nov-94	-0.68	0.9	54	1.132	n.s.
Nov-95	-0.46	0.9			
Longitudinal sample 1: Pre-school population estimated mean annual WAZ change (n=55)					
Nov-94	-1.48	0.8	54	2.142	0.037
Nov-95	-1.29	0.8			

Table 6.7.15: *Paired t-test comparing baseline and final anthropometric HA, BMI, WH and WA Z-scores to estimate intra-annual change in nutritional status for pre-school children*

Longitudinal sample 1: Pre-school population estimated mean absolute annual change anthropometric status by anthropometric indicator and gender controlling for age										
Survey	**Total Pop.n=55**		**Male n=24**		**Femalen=31**		**Main effect**	**df**	**F**	***p***
round	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual HAZ	-0.02	0.3	-0.14	0.4	0.10	0.4	Annual HAZ * age	1	21.041	<0.001
							Annual HAZ * gender	1	5.529	0.023
Longitudinal sample 1: Pre-school population absolute annual BMIZ change by gender										
Annual BMIZ	0.12	0.7	0.14	0.7	0.10	0.7	Annual BMIZ * age	1	0.010	n.s.
							Annual BMIZ * gender	1	0.028	n.s.
Longitudinal sample 1: Pre-school population absolute annual WHZ change by gender										
Annual WHZ	0.23	0.9	0.30	0.9	0.16	0.9	Annual WHZ * age	1	0.005	n.s.
							Annual WHZ * gender	1	0.292	n.s.
Longitudinal sample 1: Pre-age population absolute annual WAZ change by gender										
Annual WAZ	0.18	0.7	0.12	0.7	0.24	0.7	Annual WAZ * age	1	1.392	n.s.
							Annual WAZ * gender	1	0.446	n.s.

Table 6.7.16: *One-way ANCOVA comparing baseline and final anthropometric HA, BMI, WH and WA Z-scores by gender controlling for age to estimate intra-annual change in male and female nutritional status for pre-school children (n=55)*

Survey round	Total Pop. n=73 Mean	SD	Male n=33 Mean	SD	Female n=40 Mean	SD	Main effect	df	F	*p*
Longitudinal sample 1: Primary school-aged children estimated mean HAZ by gender and survey round										
Nov-94	-0.97	0.9	-0.96	0.9	-0.98	0.9	HAZ	2.63	5.445	0.002
Mar-95	-1.03	0.9	-1.04	0.9	-1.01	0.9	HAZ * age	2.63	7.891	<0.001
Jul-95	-1.01	0.9	-1.03	0.9	-1.00	0.9	HAZ * gender	2.63	1.059	n.s.
Nov-95	-1.07	0.9	-1.05	0.9	-1.08	0.9				
Longitudinal sample 1: Primary school-aged children estimated mean BMIZ by gender and survey round										
Nov-94	-1.23	1.1	-1.32	1.1	-1.13	1.1	BMIZ	2.23	7.487	<0.001
Mar-95	-0.85	0.9	-0.83	0.9	-0.88	0.9	BMIZ * age	2.23	4.206	0.013
Jul-95	-0.75	0.7	-0.72	0.7	-0.78	0.7	BMIZ * gender	2.23	1.999	n.s.
Nov-95	-1.05	0.8	-1.08	0.8	-1.02	0.8				
Longitudinal sample 1: Primary school-aged children estimated mean WHZ by gender and survey round										
Nov-94	-0.91	0.8	-0.97	0.8	-0.86	0.7	WHZ	2.93	6.902	<0.001
Mar-95	-0.60	0.7	-0.60	0.7	-0.59	0.7	WHZ * age	2.93	3.750	0.013
Jul-95	-0.51	0.7	-0.50	0.7	-0.51	0.7	WHZ * gender	2.93	1.162	n.s.
Nov-95	-0.73	0.7	-0.79	0.7	-0.68	0.7				
Longitudinal sample 1: Primary school-aged children estimated mean WAZ by gender and survey round										
Nov-94	-1.26	0.8	-1.32	0.8	-1.19	0.8	WAZ	2.9	17.373	<0.001
Mar-95	-1.10	0.8	-1.14	0.8	-1.07	0.8	WAZ * age	2.9	12.412	<0.001
Jul-95	-1.05	0.7	-1.08	0.7	-1.02	0.7	WAZ * gender	2.9	0.686	n.s.
Nov-95	-1.23	0.7	-1.27	0.7	-1.19	0.7				

Table 6..7.17: *Repeat measure ANCOVA within-subject effect of age after controlling for age on seasonal anthropometric indices for longitudinal sample 1 primary school-aged children (n=73)*

Survey round	Total Pop. n=73		Male n=33		Female n=40		Main within subject effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Longitudinal sample 1: Primary-school-aged children absolute seasonal HAZ by gender and season										
Pre-harvest	-0.052	0.2	-0.074	0.2	-0.030	0.2	Delta HAZ	2	0.744	n.s.
Harvest	0.014	0.2	0.010	0.2	0.017	0.2	Delta HAZ * age	2	0.702	n.s.
Post-harvest	-0.053	0.1	-0.028	0.1	-0.079	0.1	Delta HAZ * gender	2	1.467	n.s.
Longitudinal sample 1: Primary-school-aged children absolute seasonal BMIZ by gender and season										
Pre-harvest	0.37	0.6	0.49	0.6	0.25	0.6	Delta BMIZ	1.95	6.661	0.002
Harvest	0.10	0.4	0.11	0.4	0.097	0.4	Delta BMIZ * age	1.95	3.485	0.035
Post-harvest	-0.30	0.4	-0.36	0.4	-0.23	0.4	Delta BMIZ * gender	1.95	2.393	n.s.
Longitudinal sample 1: Primary-school-aged children absolute seasonal WHZ by gender and season										
Pre-harvest	0.32	0.4	0.37	0.4	0.26	0.4	Delta WHZ	2	6.171	0.003
Harvest	0.089	0.3	0.094	0.3	0.085	0.3	Delta WHZ * age	2	3.995	0.021
Post-harvest	-0.23	0.3	-0.29	0.3	-0.17	0.3	Delta WHZ * gender	2	1.380	n.s.
Longitudinal sample 1: Primary-school-aged children absolute seasonal WAZ by gender and season										
Pre-harvest	0.15	0.2	0.18	0.2	0.13	0.2	Delta WAZ	2	15.022	<0.001
Harvest	0.056	0.2	0.062	0.2	0.051	0.2	Delta WAZ * age	2	8.308	<0.001
Post-harvest	-0.18	0.2	-0.19	0.2	-0.18	0.2	Delta WAZ * gender	2	0.498	n.s.

Table 6.7.18: Repeat measure ANCOVA within-subject effect of age after controlling for age on 4-monthly seasonal changes in anthropometric indices for longitudinal sample 1 primary school-aged children (n=73)

Longitudinal sample 1: Primary school-aged population annual HAZ change					
	Mean	SD	df	t	*p*
Nov-94	-0.97	0.9	72	3.966	<0.001
Nov-95	-1.07	0.8			
Longitudinal sample 1: Primary school-aged population annual BMIZ change					
Nov-94			72	2.246	0.028
Nov-95					
Longitudinal sample 1: Primary school-aged population annual WHZ change					
Nov-94	-0.91	0.7	72	4.274	<0.001
Nov-95	-0.73	0.7			
Longitudinal sample 1: Primary school-aged population annual WAZ change					
Nov-94	-1.25	0.8	72	0.740	n.s.
Nov-95	-1.23	0.7			

Table 6.7.19: *Paired t-test comparing baseline and final anthropometric HA, BMI, WH and WA Z-scores to estimate intra-annual change in nutritional status for primary school-aged children (n=73)*

Longitudinal sample 1: Primary school-aged population absolute annual HAZ change by gender										
Survey round	Total Pop. n=73		Male n=33		Female n=40		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	-0.092	0.2	-0.092	0.2	-0.091	0.2	Annual HAZ * age	1	16.272	<0.001
							Annual HAZ * gender	1	0.000	n.s.
Longitudinal sample 1: Primary school-aged population absolute annual BMIZ change by gender										
Annual	0.18	0.6	0.24	0.6	0.12	0.6	Annual BMIZ * age	1	3.361	n.s.
							Annual BMIZ * gender	1	0.884	n.s.
Longitudinal sample 1: Primary school-aged population absolute annual WHZ change by gender										
Annual	0.18	0.4	0.18	0.4	0.18	0.4	Annual WHZ * age	1	1.911	n.s.
							Annual WHZ * gender	1	0.001	n.s.
Longitudinal sample 1: Primary school-aged population absolute annual WAZ change by gender										
Annual	0.03	0.2	0.05	0.2	-0.0003	0.2	Annual WAZ * age	1	11.803	0.001
							Annual WAZ * gender	1	0.779	n.s.

Table 6.7.20: *One-way ANCOVA comparing baseline and final anthropometric HA, BMI, WH and WA Z-scores by gender controlling for age to estimate intra-annual change in male and female nutritional status for primary school-aged children (n=73)*

Longitudinal sample 1: Adolescents adjusted mean HAZ by gender and survey round										
Survey	**Total Pop.n=60**		**Male n=24**		**Female n=36**		**Main effect**	**df**	**F**	***p***
round	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Nov-94	-1.40	1.0	-1.36	1.0	-1.43	1.0	HAZ	1.8	9.876	<0.001
Mar-95	-1.44	1.0	-1.44	1.0	-1.45	1.0	HAZ * age	1.8	7.361	0.001
Jul-95	-1.47	1.0	-1.48	1.0	-1.45	1.0	HAZ * gender	1.8	2.204	n.s.
Nov-95	-1.52	1.0	-1.54	1.0	-1.50	1.0				
Longitudinal sample 1: Adolescents adjusted mean BMIZ by gender and survey round										
Nov-94	-1.20	0.8	-1.54	0.8	-0.87	0.8	BMIZ	2.9	3.976	0.010
Mar-95	-1.05	0.8	-1.38	0.8	-0.72	0.8	BMIZ * age	2.9	4.589	0.005
Jul-95	-1.04	0.7	-1.42	0.7	-0.66	0.7	BMIZ * gender	2.9	2.001	n.s.
Nov-95	-1.15	0.8	-1.59	0.8	-0.72	0.8				

Table 6.7.21: Repeat measure ANCOVA within-subject effect of age after controlling for age on seasonal anthropometric indices for longitudinal sample 1 adolescents (n=60)

Longitudinal sample 1: Adolescents seasonal HAZ by gender and season										
Survey	**Total Pop. n=60**		**Male n=24**		**Female n=36**		**Main within**	**df**	**F**	***p***
round	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**subject effect**			
Pre-harvest	-0.046	0.1	-0.075	0.1	-0.016	0.1	Delta HAZ	2	0.449	n.s.
Harvest	-0.022	0.1	-0.040	0.1	-0.041	0.1	Delta HAZ * age	2	0.343	n.s.
Post-harvest	-0.057	0.1	-0.067	0.1	-0.048	0.1	Delta HAZ * gender	2	0.325	n.s.
Longitudinal sample 1: Adolescents seasonal BMIZ by gender and season										
Pre-harvest	0.16	0.3	0.16	0.3	0.15	0.3	Delta BMIZ	2	0.025	n.s.
Harvest	0.075	0.3	-0.039	0.3	0.054	0.3	Delta BMIZ * age	2	0.101	n.s.
Post-harvest	-0.12	0.4	-0.17	0.4	-0.061	0.4	Delta BMIZ * gender	2	0.382	n.s.

Table 6.7.22: Repeat measure ANCOVA within-subject effect of age after controlling for age on 4-monthly seasonal changes in anthropometric indices for longitudinal sample 1 adolescents (n=60)

Longitudinal sample 1: Adolescent population annual HAZ change by gender					
	Mean	**SD**	**df**	**t**	***p***
Nov-94	-1.40	1.0	59	3.345	0.001
Nov-95	-1.51	1.0			
Longitudinal sample 1: Adolescent population annual BMIZ change by gender					
Nov-94	-1.13	0.8	59	1.308	n.s.
Nov-95	-1.07	0.9			

Table 6.7.23: *Paired t-test comparing baseline and final anthropometric HA, BMI Z-scores to estimate intra-annual change in nutritional status for adolescents (n=60)*

Longitudinal sample 1: Adolescent population absolute annual HAZ change by gender										
Survey round	**Total Pop. =60**		**Male n=24**		**Female n=36**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	-0.13	0.2	-0.18	0.2	-0.068	0.2	Annual HAZ * age	1	8.240	0.006
							Annual HAZ * gender	1	2.873	n.s.
Longitudinal sample 1: Adolescent population absolute annual BMIZ change by gender										
Annual	0.048	0.4	-0.051	0.4	0.15	0.4	Annual BMIZ * age	1	8.353	0.005
							Annual BMIZ * gender	1	3.801	0.056

Table 6.7.24: *One-way ANCOVA comparing baseline and final anthropometric HA, BMI Z-scores by gender controlling for age to estimate intra-annual change in male and female nutritional status for adolescents (n=60)*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly HAZ by yearly age classes and season											
Yearly		*Pre-harvest*		*Harvest*		*Post-harvest*					
age class	n	Mean	SD	Mean	SD	Mean	SD	Main effect	df	F	*p*
0-11	12	0.73	0.6	-0.91	0.6	-0.14	0.5				
12-23	16	-0.22	0.5	-0.20	0.5	0.05	0.4	Absolute HAZ change	1.95	5.402	0.006
24-35	14	0.14	0.5	-0.02	0.5	-0.05	0.4	Absolute HAZ change * yearly age class	7.82	5.101	<0.001
36-48	20	-0.05	0.5	0.11	0.5	0.03	0.3				
48-59	20	-0.03	0.5	0.13	0.4	0.09	0.3				
Longitudinal sample 1: Primary school-aged children estimated mean absolute seasonal 4-monthly HAZ changes by yearly age classes and season											
5-5.99	9	0.008	0.2	0.03	0.2	0.003	0.1				
6-6.99	14	-0.02	0.2	0.05	0.2	-0.06	0.1				
7-7.99	17	-0.02	0.2	0.03	0.2	-0.10	0.1	Absolute HAZ change	1.80	3.166	0.051
8-8.99	16	-0.09	0.2	0.006	0.2	-0.009	0.1	Absolute HAZ change * yearly age class	7.18	0.614	n.s.
9-9.99	17	-0.10	0.2	-0.04	0.2	-0.08	0.1				
Longitudinal sample 1: Adolescent estimated mean absolute seasonal 4-monthly HAZ by yearly age classes and season											
10-10.99	17	-0.06	0.2	-0.07	0.1	0.10	0.1				
11-11.99	10	-0.11	0.2	-0.01	0.1	-0.01	0.1				
12-12.99	12	-0.03	0.2	0.04	0.1	-0.01	0.1				
13-13.99	5	-0.06	0.2	-0.01	0.1	-0.13	0.1	Absolute HAZ change	2	0.950	n.s.
14-14.99	8	0.008	0.2	-0.04	0.1	-0.005	0.1	Absolute HAZ change * yearly age class	14	0.522	n.s.
15-15.99	3	0.04	0.2	-0.01	0.1	-0.06	0.1				
16-16.99	2	0.00	0.2	0.01	0.1	-0.06	0.1				
17-17.99	3	0.07	0.2	0.04	0.1	0.05	0.1				

Table 6.7.25: *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute HAZ changes for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly BMIZ by yearly age classes and season											
Yearly		*Pre-harvest*		*Harvest*		*Post-harvest*					
age class	n	Mean	SD	Mean	SD	Mean	SD	Main effect	df	F	*p*
24-35	9	0.076	0.8	0.37	0.9	-0.52	0.6	Absolute BMIZ change	1.77	7.337	0.002
36-48	15	0.41	0.8	0.24	0.9	-0.46	0.6	Absolute BMIZ change * yearly age class	1.77	0.637	n.s.
48-59	16	0.0038	0.8	0.40	0.9	-0.24	0.6				
Longitudinal sample 1: Primary school-aged children estimated mean absolute seasonal 4-monthly BMIZ changes by yearly age classes and season											
5-5.99	9	0.41	0.6	0.54	0.4	-0.59	0.3				
6-6.99	14	0.48	0.6	0.22	0.4	-0.38	0.3	Absolute BMIZ change	1.9	32.691	<0.001
7-7.99	17	0.30	0.6	0.04	0.4	-0.15	0.3	Absolute BMIZ change * yearly age class	7.6	2.048	0.048
8-8.99	16	0.43	0.6	-0.08	0.4	-0.15	0.3				
9-9.99	17	0.24	0.6	0.01	0.4	-0.33	0.3				
Longitudinal sample 1: Adolescent estimated mean absolute seasonal 4-monthly BMIZ by yearly age classes and season											
10-10.99	17	-0.01	0.3	0.07	0.3	-0.16	0.3				
11-11.99	10	0.21	0.3	0.06	0.3	-0.26	0.3				
12-12.99	12	0.34	0.3	-0.19	0.3	-0.02	0.3	Absolute BMIZ change	2	7.384	0.001
13-13.99	5	-0.02	0.3	0.04	0.3	-0.09	0.3	Absolute BMIZ change * yearly age class	14	1.361	n.s.
14-14.99	8	0.13	0.3	0.08	0.3	0.12	0.3				
15-15.99	3	0.29	0.3	0.25	0.3	-0.01	0.3				
16-16.99	2	0.18	0.3	0.08	0.3	-0.48	0.3				
17-17.99	3	0.37	0.3	0.20	0.3	-0.11	0.3				

Table 6.7.26: *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute BMIZ changes for longitudinal sample 1: by pre-school (n=40), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly WHZ by yearly age classes										
Yearly		*Pre-harvest*		*Harvest*		*Post-harvest*				
age class	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	12	-0.75	0.6	0.52	0.6	-0.83	0.6				
12-23	16	0.63	0.6	0.38	0.6	0.11	0.6	Absolute WHZ change	2	12.458	<0.001
24-35	14	0.07	0.6	0.29	0.6	-0.40	0.5	Absolute WHZ change * yearly age class	8	1.487	n.s.
36-48	20	0.33	0.6	0.23	0.6	-0.31	0.5				
48-59	20	0.07	0.6	0.31	0.6	-0.19	0.5				
Longitudinal sample 1: Primary school-aged children estimated mean absolute seasonal 4-monthly WHZ changes by yearly age classes											
5-5.99	9	0.28	0.4	0.44	0.3	-0.45	0.3				
6-6.99	14	0.34	0.4	0.16	0.3	-0.29	0.3				
7-7.99	17	0.28	0.4	0.04	0.3	-0.12	0.3	Absolute WHZ change	2	32.234	<0.001
8-8.99	16	0.39	0.4	-0.05	0.3	-0.11	0.3	Absolute WHZ change * yearly age class	8	1.889	n.s.
9-9.99	17	0.29	0.4	0.005	0.3	-0.26	0.3				

Table 6.7.27: *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute WHZ changes for longitudinal sample 1: by pre-school (n=55), and primary school-aged (n=73) population*

Longitudinal sample 1: Pre-school estimated mean absolute seasonal 4-monthly WAZ by yearly age classes											
Yearly		*Pre-harvest*		*Harvest*		*Post-harvest*					
age class	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	12	0.04	0.7	-0.05	0.8	-0.52	0.6				
12-23	16	0.43	0.5	0.16	0.6	-0.13	0.5	Absolute WAZ change	1.9	11.789	<0.001
24-35	14	0.16	0.5	0.19	0.6	-0.32	0.5	Absolute WAZ change * yearly age class	7.8	0.713	n.s.
36-48	20	0.24	0.5	0.25	0.6	-0.21	0.5				
48-59	20	0.03	0.5	0.30	0.6	-0.08	0.4				
Longitudinal sample 1: Primary school-aged children estimated mean absolute seasonal 4-monthly WAZ changes by yearly age classes											
5-5.99	9	0.20	0.2	0.31	0.2	-0.33	0.2				
6-6.99	14	0.22	0.2	0.14	0.2	-0.24	0.2				
7-7.99	17	0.15	0.2	0.03	0.2	-0.15	0.2	Absolute WAZ change	2	54.313	<0.001
8-8.99	16	0.14	0.2	-0.05	0.2	-0.08	0.2	Absolute WAZ change * yearly age class	8	3.793	<0.001
9-9.99	17	0.08	0.2	-0.02	0.2	-0.19	0.2				

Table 6.7.28: *Repeat measures ANOVA within-subject effect of yearly age classes on seasonal estimated 4-monthly mean absolute HAZ changes for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Pre-school estimated mean change in HAZ and BMIZ by yearly age classes														
	Annual change in HAZ							**Annual change in BMIZ**						
	n	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	5	-0.31	0.4					†					
12-23	10	-0.37	0.4					†					
24-35	9	0.06	0.4	Yearly age classes	4	4.460	0.004	-0.7	0.7	Yearly age classes	4	0.489	n.s.
36-48	15	0.09	0.4					0.19	0.7				
48-59	16	0.18	0.4					0.16	0.7				
Longitudinal sample 1: Primary school-aged population estimated mean change in HAZ and BMIZ by yearly age classes													
5-5.99	9	0.04	0.2					0.35	0.6				
6-6.99	14	-0.03	0.2					0.31	0.6				
7-7.99	17	-0.08	0.2	Yearly age classes	4	3.634	0.010	0.19	0.6	Yearly age classes	4	1.288	n.s.
8-8.99	16	-0.09	0.2					0.20	0.6				
9-9.99	17	-0.22	0.2					-0.08	0.6				
Longitudinal sample 1: Adolescent population estimated mean change in HAZ and BMIZ by yearly age classes													
10-10.99	17	-0.23	0.3					-0.09	0.4				
11-11.99	10	-0.18	0.3					-0.08	0.4				
12-12.99	12	-0.005	0.3					0.13	0.4				
13-13.99	5	-0.20	0.3	Yearly age classes	7	1.703	n.s.	-0.07	0.4	Yearly age classes	7	2.965	0.011
14-14.99	8	-0.04	0.3					0.33	0.4				
15-15.99	3	-0.03	0.3					0.54	0.4				
16-16.99	2	-0006	0.3					-0.22	0.4				
17-17.99	3	0.16	0.3					0.46	0.4				

Table 6.7.29: *One-way ANOVA within-subject effect of yearly age classes on estimated mean change in HAZ and BMIZ for longitudinal sample 1: by pre-school (n=55), primary school-aged (n=73) and adolescents (n=60) population*

Longitudinal sample 1: Pre-school estimated mean change in WHZ and WAZ by yearly age classes													
	Annual change in WHZ							Annual change in WAZ					
	n	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***	**Mean**	**SD**	**Main effect**	**df**	**F**	***p***
0-11	5	-1.01	0.7					-0.53	0.6				
12-23	10	1.11	0.7					0.45	0.6				
24-35	9	-0.04	0.7	Yearly age classes	4	7.677	<0.001	0.04	0.6	Yearly age classes	4	2.381	n.s.
36-48	15	0.25	0.7					0.28	0.6				
48-59	16	0.18	0.7					0.25	0.6				
Longitudinal sample 1: Primary school-aged population estimated mean change in HAZ and BMIZ by yearly age classes													
5-5.99	9	0.26	0.4					0.18	0.2				
6-6.99	14	0.22	0.4					0.12	0.2				
7-7.99	17	0.21	0.4	Yearly age classes	4	0.979	n.s.	0.03	0.2	Yearly age classes	4	3.0139	0.020
8-8.99	16	0.23	0.4					0.008	0.2				
9-9.99	17	0.02	0.4					-0.13	0.2				

Table 6.7.30: *One-way ANOVA within-subject effect of yearly age classes on estimated mean change in WHZ and WAZ for longitudinal sample 1: by pre-school (n=55) and primary school-aged (n=73) population*

Tables for Section 6.8

Longitudinal sample 1: Pre-school children (0-4.99 years) absolute seasonal weight increments (kg) by initial weight status										
Survey round	**Total Pop. n=55**		**Adequate WH n=45**		**Thin (<-1.5 WH) n=10**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	0.81	0.8	0.91	0.7	0.71	0.7	Absolute weight increments	1.95	5.499	0.006
Harvest	1.09	0.9	0.92	0.7	1.27	0.7	Absolute weight increments * age	1.95	4.139	0.019
Post-harvest	0.28	0.8	0.27	0.6	0.29	0.6	Absolute wt increments * initial wt status	1.95	1.216	n.s.
Longitudinal sample 1: Pre-school children (0-4.99 years) absolute seasonal weight increments (kg) by initial height status										
	Total Pop. n=55		**Adequate HA n=40**		**Stunted (<-2 HAZ) n=15**		**Main effect**	**df**	**F**	***p***
Pre-harvest	0.87	0.7	0.88	0.7	0.85	0.7	Absolute weight increments	1.94	5.438	0.006
Harvest	0.92	0.8	1.05	0.7	0.80	0.7	Absolute weight increments * age	1.94	3.985	0.023
Post-harvest	0.30	0.7	0.24	0.6	0.37	0.6	Absolute wt increments * initial ht status	1.94	0.718	n.s.

Table 6.8.4: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal weight increments (kg) for pre-school children (0-4.99 years) (n=55).*

Longitudinal sample 1: Pre-school children (0-4.99 years) absolute seasonal height increments (cm) by initial weight status										
Survey round	**Total Pop. n=55**		**Adequate WH n=45**		**Thin (<-1.5 WH) n=10**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	2.73	2.3	2.79	1.8	2.66	1.8	Absolute height increments	1.59	10.016	<0.001
Harvest	2.34	1.9	2.58	1.4	2.11	1.4	Absolute height increments * age	1.59	9.746	<0.001
Post-harvest	2.22	1.5	2.61	1.1	1.83	1.1	Absolute height increments * initial weight status	1.59	0.328	n.s.
Longitudinal sample 1: Pre-school children (0-4.99 years) absolute seasonal height increments (cm) by initial height status										
	Total Pop. n=55		**Adequate HA n=40**		**Stunted (<-2 HAZ) n=15**		**Main effect**	**df**	**F**	***p***
Pre-harvest	3.01	1.9	2.48	1.7	3.53	1.7	Absolute height increments	1.75	13.813	<0.001
Harvest	2.32	1.6	2.70	1.4	1.93	1.4	Absolute height increments * age	1.75	12.308	<0.001
Post-harvest	2.44	1.3	2.50	1.2	2.39	1.2	Absolute ht increments * initial ht status	1.75	3.668	0.035

Table 6.8.5: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal height increments (cm) for pre-school children (0-4.99 years) (n=55).*

Longitudinal sample 1: Pre-school children (0-4.99 years) absolute annual weight velocity (kg) by initial weight status										
Survey round	**Total Pop. n=55**		**Adequate WHZ n=45**		**Thin (<-1.5 WHZ) n=10**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	2.19	1.0	2.09	0.8	2.28	0.8	Annual weight increments * age	1	3.730	n.s.
							Annual weight increments * initial weight status	1	0.420	n.s.
Longitudinal sample 1: Pre-school children (0-4.99 years) absolute annual weight velocity (kg) by initial height status										
	Total Pop. n=55		**Adequate HA n=40**		**Stunted (<-2 HAZ) n=15**		**Main effect**	**df**	**F**	***p***
Annual	2.09	0.9	2.17	0.8	2.02	0.8	Annual weight increments * age	1	3.728	n.s.
							Annual weight increments * initial height status	1	0.388	n.s.
Longitudinal sample 1: Pre-school children (0-4.99 years) absolute annual height velocity (kg) by initial weight status										
Survey round	**Total Pop. n=55**		**Adequate WHZ n=45**		**Thin (<-1.5 WHZ) n=10**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	7.45	2.1	7.89	1.6	7.00	1.6	Annual weight increments * age	1	28.474	<0.001
							Annual weight increments * age^2	1	11.343	0.001
							Annual weight increments * age^3	1	19.511	<0.001
							Annual weight increments * initial weight status	1	2.417	n.s.
Longitudinal sample 1: Pre-school children (0-4.99 years) absolute annual height velocity (kg) by initial height status										
	Total Pop. n=55		**Adequate HA n=40**		**Stunted (<-2 HAZ) n=15**		**Main effect**	**df**	**F**	***p***
Annual	7.80	1.8	7.64	1.6	7.96	1.6	Annual weight increments * age	1	27.387	<0.001
							Annual weight increments * age^2	1	10.910	0.002
							Annual weight increments * age^3	1	18.766	0.001
							Annual weight increments * initial height status	1	0.415	n.s.

Table 6.8.6: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute annual weight (kg) and height velocities (cm) for pre-school children (0-4.99 years) (n=55).*

Longitudinal sample 1: Primary school-aged (5-9.99 years) absolute seasonal weight increments (kg) by initial weight status										
Survey round	**Total Pop. n=70**		**Adequate WH n=57**		**Thin (<-1.5 WH) n=13**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	1.30	0.9	1.07	0.7	1.53	0.7	Absolute weight increments	2	5.408	0.006
Harvest	0.90	0.7	0.85	0.5	0.94	0.6	Absolute weight increments * age	2	3.347	0.038
Post-harvest	0.16	0.9	0.21	0.7	0.12	0.7	Absolute weight increments * initial weight status	2	1.636	n.s.
Longitudinal sample 1: Primary school-aged (5-9.99 years) absolute seasonal weight increments (kg) by initial height status										
	Total Pop. n=73		**Adequate HA n=66**		**Stunted (<-2 HAZ) n=7**		**Main effect**	**df**	**F**	***p***
Pre-harvest	1.008	1.2	1.203	0.7	0.822	0.7	Absolute weight increments	2	5.152	0.007
Harvest	1.066	1.0	0.842	0.6	1.290	0.6	Absolute weight increments * age	2	1.887	n.s.
Post-harvest	-0.106	1.2	0.229	0.7	-0.441	0.7	Absolute wt increments * initial height status	2	4.267	0.016

Table 6.8.7: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal weight increments (kg) for primary school-aged children (5-9.99 years) (n=73).*

Longitudinal sample 1: Primary school-aged (5-9.99 years) absolute seasonal height increments (cm) by initial weight status										
Survey round	**Total Pop. n=73**		**Adequate WH n=57**		**Thin (<-1.5 WH) n=13**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Pre-harvest	1.34	1.3	1.40	1.0	1.28	1.0	Absolute height increments	1.86	0.763	n.s.
Harvest	1.79	1.1	1.77	0.8	1.81	0.9	Absolute height increments * age	1.86	0.915	n.s.
Post-harvest	1.50	1.0	1.49	0.7	1.50	0.8	Absolute ht increments * initial weight status	1.86	0.082	n.s.
Longitudinal sample 1: Primary school-aged (5-9.99 years) absolute seasonal height increments (cm) by initial height status										
	Total Pop. n=73		**Adequate HA n=66**		**Stunted (<-2 HAZ) n=7**		**Main effect**	**df**	**F**	***p***
Pre-harvest	1.32	1.6	1.37	1.0	1.26	1.0	Absolute height increments	1.84	0.873	n.s.
Harvest	1.84	1.5	1.82	0.9	1.86	0.9	Absolute height increments * age	1.84	1.254	n.s.
Post-harvest	1.48	1.3	1.53	0.7	1.43	0.7	Absolute ht increments * initial ht status	1.84	0.045	n.s.

Table 6.8.8: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal height increments (cm) for primary school-aged children (5-9.99 years) (n=73).*

Longitudinal sample 1: Primary school-aged children (5-9.99 years) absolute annual weight velocity (kg) by initial weight status									
Survey round	Total Pop. n=73		Adequate WHZ n=57		Thin (<-1.5 WHZ) n=13		Main effect	df	t	p
	Mean	SD	Mean	SD	Mean	SD				
Annual	2.34	1.1	2.15	0.8	2.54	0.8	Annual weight increments * initial weight status	1	1.442	n.s.
Longitudinal sample 1: Primary school-aged children (5-9.99 years) absolute annual weight velocity (kg) by initial height status										
	Total Pop. n=73		**Adequate HA n=66**		**Stunted (<-2 HAZ) n=7**		**Main effect**	**df**	**t**	***p***
Annual	1.96	1.5	2.28	0.9	1.64	0.7	Annual weight increments * initial height status	1	1.799	n.s.
Longitudinal sample 1: Primary school-aged children (5-9.99 years) absolute annual height velocity (cm) by initial weight status										
Survey round	**Total Pop. n=73**		**Adequate WHZ n=57**		**Thin (<-1.5 WHZ) n=13**		**Main effect**	**df**	**F**	***p***
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Annual	4.62	1.3	4.66	1.0	4.59	1.0	Annual height increments * age	1	18.434	<0.001
							Annual height increments * initial weight status	1	0.050	n.s.
Longitudinal sample 1: Primary school-aged children (5-9.99 years) absolute annual height velocity (cm) by initial height status										
	Total Pop. n=73		**Adequate HA n=66**		**Stunted (<-2 HAZ) n=7**		**Main effect**	**df**	**F**	***p***
Annual	4.64	1.8	4.72	1.0	4.56	1.1	Annual height increments * age	1	12.214	0.001
							Annual height increments * initial height status	1	0.143	n.s.

Table 6.8.9: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute annual weight (kg) and height velocities (cm) for primary school-aged children (5-9.99 years) (n=73)*

Longitudinal sample 1: Adolescent (10-17.99 years) absolute seasonal weight increments (kg) by initial weight status										
Survey round	Total Pop. n=60		Adequate BMI n=51		Thin (<-2 BMIZ) n=9		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.44	1.5	1.71	1.1	1.17	1.1	Absolute weight increments	2	5.016	0.055
Harvest	1.16	1.6	1.22	1.2	1.10	1.2	Absolute weight increments * age	2	6.711	0.021
Post-harvest	1.04	2.0	0.49	1.4	1.59	1.4	Absolute weight increments * initial weight status	2	5.371	0.045
Longitudinal sample 1: Adolescent (10-17.99 years) absolute seasonal weight increments (kg) by initial height status										
	Total Pop. n=60		Adequate HA n=45		Stunted (<-2 HAZ) n=15		Main effect	df	F	*p*
Pre-harvest	1.62	1.2	1.63	1.1	1.61	1.1	Absolute weight increments	2	1.527	n.s.
Harvest	1.07	1.3	1.33	1.1	0.81	1.1	Absolute weight increments * age	2	2.826	n.s.
Post-harvest	0.70	1.7	0.60	1.4	0.80	1.4	Absolute weight increments * initial height status	2	0.874	n.s.

Table 6.8.10: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal weight increments (kg) for adolescents (10-17.99 years) (n=60).*

Longitudinal sample 1: Adolescent (10-17.99 years) absolute seasonal height increments (cm) by initial weight status										
Survey round	Total Pop. n=60		Adequate BMI n=51		Thin (<-2 BMIZ) n=9		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Pre-harvest	1.52	1.4	1.23	1.0	1.82	1.0	Absolute height increments	2	1.212	n.s.
Harvest	1.68	1.2	1.48	0.9	1.89	0.9	Absolute height increments * age	2	1.024	n.s.
Post-harvest	1.73	1.2	1.16	0.8	2.30	0.8	Absolute height increments * initial weight status	2	1.273	n.s.
Longitudinal sample 1: Adolescent (10-17.99 years) absolute seasonal height increments (cm) by initial height status										
	Total Pop. n=60		Adequate HA n=45		Stunted (<-2 HAZ) n=15		Main effect	df	F	*p*
Pre-harvest	1.39	1.1	1.25	1.0	1.54	1.0	Absolute height increments	2	0.954	n.s.
Harvest	1.50	1.0	1.57	0.9	1.43	0.9	Absolute height increments * age	2	0.889	n.s.
Post-harvest	1.41	1.0	1.26	0.9	1.55	0.9	Absolute height increments * initial height status	2	0.830	n.s.

Table 6.8.11: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute seasonal height increments (cm) for adolescents (10-17.99 years) (n=60).*

Longitudinal sample 1: Adolescent (10-17.99 years) absolute annual weight velocity (kg) by initial weight status										
Survey round	Total Pop. n=60		Adequate BMI n=51		Thin (<-2 BMIZ) n=9		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	3.64	2.5	3.42	1.8	3.85	1.8	Annual weight increments * age	1	4.465	0.039
							Annual weight increments * initial weight status	1	0.454	n.s.
Longitudinal sample 1: Adolescent (10-17.99 years) absolute annual weight velocity (kg) by initial height status										
	Total Pop. n=60		Adequate HA n=45		Stunted (<-2 HAZ) n=15		Main effect	df	F	*p*
Annual	3.40	2.0	3.57	1.8	3.22	1.8	Annual weight increments * age	1	4.463	0.039
							Annual weight increments * initial height status	1	0.435	n.s.
Longitudinal sample 1: Adolescent (10-17.99 years) absolute annual height velocity (cm) by initial weight status										
Survey round	Total Pop. n=60		Adequate BMI n=51		Thin (<-2 BMIZ) n=9		Main effect	df	F	*p*
	Mean	SD	Mean	SD	Mean	SD				
Annual	4.94	2.0	3.87	1.3	6.01	1.9	Annual weight increments * age	1	31.759	<0.001
							Annual weight increments * initial weight status	1	16.928	<0.001
Longitudinal sample 1: Adolescent (10-17.99 years) absolute annual height velocity (cm) by initial height status										
	Total Pop. n=60		Adequate HA n=45		Stunted (<-2 HAZ) n=15		Main effect	df	F	*p*
Annual	4.30	1.9	4.08	1.6	4.52	1.6	Annual weight increments * age	1	24.860	<0.001
							Annual weight increments * initial height status	1	0.868	n.s.

Table 6.8.12: *Repeat measures ANCOVA within and between-subject effect of initial weight and height status after controlling for age on absolute annual weight (kg) and height velocities (cm) for adolescents (10-17.99 years) (n=60).*

Tables for Section 6.9

The change in Seasonal Prevalence Rates in Stunting amongst Whole Population (n=188)											
Pre-harvest* [a] *(Mar-95)				***Harvest* [b] *(Jul-95)***				***Post-harvest* [c] *(Nov-95)***			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	17.0	2.7	19.7	<-2 HAZ	19.7	5.5	23.9	<-2 HAZ	19.7	3.2	22.9
≥-2 HAZ	6.9	73.4	80.3	≥-2 HAZ	3.2	72.9	76.1	≥-2 HAZ	1.6	75.5	77.7
Total	23.9	76.1	100.0		22.9	77.1	100.0		21.3	78.7	100.0

Table 6.9.1: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the whole child population*

a. χ^2=2.72, *p*=0.096; *b.* χ^2=0.07 n.s.; c.χ^2=0.44, n.s.

The change in Seasonal Prevalence Rates in Stunting amongst Whole Male Child Population (n=81)											
Pre-harvest* [a] *(Mar-95)				***Harvest* [b] *(Jul-95)***				***Post-harvest* [c] *(Nov-95)***			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	17.3	0.0	17.3	<-2 HAZ	21.0	4.9	25.9	<-2 HAZ	19.8	2.5	22.2
≥-2 HAZ	8.6	74.1	82.7	≥-2 HAZ	1.2	72.8	74.1	≥-2 HAZ	2.5	75.3	77.8
Total	25.9	74.1	100.0		22.2	77.8	100.0		22.2	77.8	100.0

Table 6.9.2: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the whole male child population*

χ^2=5.114, *p*=0.016; *b.* χ^2=0.8 n.s.; c.χ^2=0.25, n.s.

The change in Seasonal Prevalence Rates in Stunting amongst Whole Female Child Population (n=107)											
Pre-harvest* [a] *(Mar-95)				***Harvest* [b] *(Jul-95)***				***Post-harvest* [c] *(Nov-95)***			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	16.8	4.7	21.5	<-2 HAZ	18.7	3.7	22.4	<-2 HAZ	19.6	3.7	23.4
≥-2 HAZ	5.6	72.9	78.5	≥-2 HAZ	4.7	72.9	77.6	≥-2 HAZ	0.9	75.7	76.6
Total	21.5	77.6	100.0		23.4	76.6	100.0		20.6	79.4	100.0

Table 6.9.3: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the whole female child population*

a. χ^2=0.09, n.s; *b.* χ^2=0.11 n.s.; c.χ^2=0.20, n.s.

The change in Seasonal Prevalence Rates in Thinness amongst Whole Child Population (2-17.99 years)											
Pre-harvest [a]				*Harvest* [b]				*Post-harvest* [c]			
	Mar-95				Jul-95				Nov-95		
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	8.7	6.4	15.0	<-2 BMIZ	6.4	4.6	11.0	<-2 BMIZ	5.2	1.7	6.9
≥-2 BMIZ	2.3	82.7	85.0	≥-2 BMIZ	0.6	88.4	89.0	≥-2 BMIZ	5.2	87.9	93.1
Total	11.0	89.0	100.0		6.9	93.1	100.0		10.4	89.6	100.0

Table 6.9.4 *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the whole child population*

a. χ^2= 2.4, n.s.; *b.* χ^2= 4.0, p=0.039; c.χ^2=0.083 n.s.

The change in Seasonal Prevalence Rates in Thinness amongst Whole Male Child Population (2-17.99 years) n=78											
Pre-harvest [a]				*Harvest* [b]				*Post-harvest* [c]			
	Mar-95				Jul-95				Nov-95		
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	12.8	7.7	20.5	<-2 BMIZ	9.0	3.8	12.8	<-2 BMIZ	7.7	2.6	10.3
≥-2 BMIZ	0.0	79.5	79.5	≥-2 BMIZ	1.3	85.9	87.2	≥-2 BMIZ	7.7	82.1	89.7
Total	12.8	87.1	100.0		10.3	89.7	100.0		15.4	84.6	100.0

Table 6.9.5 *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the whole male child population*

a. χ^2=4.17, p=0.031; *b.* χ^2=0.25, n.s.; c.χ^2=1.13, n.s.

The change in Seasonal Prevalence Rates in Thinness amongst Whole Female Child Population (2-17.99 years) n=											
Pre-harvest [a]				*Harvest* [b]				*Post-harvest* [c]			
	Mar-95				Jul-95				Nov-95		
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	5.3	5.3	10.5	<-2 BMIZ	4.2	5.3	9.5	<-2 BMIZ	3.2	1.1	4.2
≥-2 BMIZ	4.2	85.3	89.5	≥-2 BMIZ	0.0	90.5	90.5	≥-2 BMIZ	3.2	92.6	95.8
Total	9.5	90.5	100.0		4.2	95.8	100.0		6.3	93.7	100.0

Table 6.9.6 *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the whole female child population*

a. χ^2=0.11, n.s.; *b.* χ^2=3.2, n.s.; c.χ^2=0.25, n.s.

The change in Seasonal Prevalence Rates in Wasting (<-2 WHZ) amongst Children aged <10 years (n=125)											
Pre-harvest [a]				***Harvest*** [b]				***Post-harvest*** [c]			
	Mar-95				Jul-95				Nov-95		
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Mar-95	<-2 WHZ	≥-2 WHZ	Total	Jul-95	<-2 WHZ	≥-2 WHZ	Total
<-2 WHZ	1.6	3.2	4.8	<-2 WHZ	0.0	6.4	6.4	<-2 WHZ	0.0	0.8	0.8
≥-2 WHZ	4.8	90.4	95.2	≥-2 WHZ	0.8	92.8	93.6	≥-2 WHZ	1.6	97.6	99.2
Total	6.4	93.6	100.0		0.8	99.2	100.0		1.6	98.4	100.0

Table 6.9.7: *Change in seasonal prevalence rates of wasting (<-2WHZ) for the whole child population aged <10 years (n=125)*

a. χ^2=0.1 , n.s.; *b.* χ^2=4.0 *p*=0.039; c.χ^2= 0.33 n.s.

The change in Seasonal Prevalence Rates in Underweight (<-2 WAZ) amongst Children aged <10 years (n=128)											
Pre-harvest [a]				***Harvest*** [b]				***Post-harvest*** [c]			
	Mar-95				Jul-95				Nov-95		
Nov-94	<-2 WAZ	≥-2 WAZ	Total	Mar-95	<-2 WAZ	≥-2 WAZ	Total	Jul-95	<-2 WAZ	≥-2 WAZ	Total
<-2 WAZ	12.5	7.0	19.5	<-2 WAZ	8.6	6.3	14.8	<-2 WAZ	10.2	0.0	10.2
≥-2 WAZ	2.3	78.1	80.5	≥-2 WAZ	1.6	83.6	85.2	≥-2 WAZ	5.5	84.4	89.8
Total	14.8	85.2	100.0		10.2	89.8	100.0		15.7	84.3	100.0

Table 6.9.8: *Change in seasonal prevalence rates of underweight (<-2 WAZ) for the whole child population aged <10 years (n=128)*

a. χ^2=2.08, n.s.; *b.* χ^2= 2.5, n.s.; c.χ^2=0.14, n.s.

The Annual change in Prevalence Rates in Stunting and Thinness amongst Whole Child Pop.							
Annual change stunting [a]				***Annual change in thinness*** [b]			
	Nov-95				Nov-95		
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Nov-94	<-2 BMIZ	≥-2 BMIZ	Total
<-2 HAZ	17.0	2.7	19.7	<-2 BMIZ	8.1	6.9	15.0
≥-2 HAZ	4.3	76.1	80.3	≥-2 BMIZ	2.3	82.7	85.0
Total	21.3	78.7	100.0		10.4	89.6	100.0

Table 6.9.9: *Change in annual prevalence rates of stunting (<-2 HAZ) and thinness (<-2 BMIZ) for the whole child population*

a. χ^2=0.31, n.s.; *b.* χ^2=3.06, n.s.;

The Annual change in Prevalence Rates in Wasting and Underweight amongst Whole Child Population <10 years old							
Annual change wasting [a]				***Annual change in underweight*** [b]			
	Nov-95				Nov-95		
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Nov-94	<-2 WAZ	≥-2 WAZ	Total
<-2 WHZ	1.6	3.2	4.8	<-2 WAZ	11.7	7.8	19.5
≥-2WHZ	0.0	95.2	95.2	≥-2 WAZ	3.9	76.6	80.5
Total	1.6	98.4	100.0		15.6	84.4	100.0

Table 6.9.10: *Change in annual prevalence rates of wasting (<-2 WHZ) and underweight (<-2 WAZ) for the whole child population aged <10 years olds*

a. χ^2=2.25, n.s.; *b.* χ^2=1.07, n.s.;

The change in Seasonal Prevalence Rates in Stunting amongst Pre-school Population											
Pre-harvest [a] (Mar-95)				*Harvest* [b] (Jul-95)				*Post-harvest* [c] (Nov-95)			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	20.0	7.3	27.3	<-2 HAZ	20.0	7.3	27.3	<-2 HAZ	21.8	7.3	29.1
≥-2 HAZ	7.3	65.5	27.3	≥-2 HAZ	9.1	63.6	72.7	≥-2 HAZ	1.8	69.1	70.9
Total	27.3	72.7	100.0		29.1	70.9	100.0		23.6	76.4	100.0

Table 6.9.11: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the pre-school population*

a. χ^2=0.13, *p*=0.096; *b.* χ^2=0.1, n.s. c.χ^2=0.8, n.s.

The change in Seasonal Prevalence Rates in Thinness (<-2 BMIZ) amongst Pre-school Population											
Pre-harvest [a] (Mar-95)				*Harvest* [b] (Jul-95)				*Post-harvest* [c] (Nov-95)			
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	5.0	5.0	10.	<-2 BMIZ	2.5	7.5	10.0	<-2 BMIZ	2.5	2.5	5.0
≥-2 BMIZ	5.0	85.0	90.0	≥-2 BMIZ	2.5	87.5	90.0	≥-2 BMIZ	7.5	87.5	95.0
Total	10.0	90.0	100.0		5.0	95.0	100.0		10.0	90.0	100.0

Table 6.9.12: *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the pre-school population*

a. χ^2=0.0 n.s. *b.* χ^2=0.25, n.s. c.χ^2=0.25, n.s.

The change in Seasonal Prevalence Rates in Wasting (<-2 WHZ) amongst Pre-school Population											
Pre-harvest [a] (Mar-95)				*Harvest* [b] (Jul-95)				*Post-harvest* [c] (Nov-95)			
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Mar-95	<-2 WHZ	≥-2 WHZ	Total	Jul-95	<-2 WHZ	≥-2 WHZ	Total
<-2 WHZ	1.8	1.8	3.6	<-2 WHZ	0.0	10.9	10.9	<-2 WHZ	0.0	1.8	1.8
≥-2 WHZ	9.1	87.3	96.4	≥-2 WHZ	1.8	87.3	89.1	≥-2 WHZ	0.0	98.2	98.2
Total	10.9	89.1	100.0		1.8	98.2	100.0		0.0	100.0	100.0

Table 6.9.13: *Change in seasonal prevalence rates of stunting (<-2 WHZ) for the pre-school population*

a. χ^2=1.5, n.s. *b.* χ^2=2.29, n.s. *c.* χ^2=0.0, n.s.

The change in Seasonal Prevalence Rates in Underweight (<-2 WAZ) amongst Pre-school Population											
Pre-harvest [a] (Mar-95)				*Harvest* [b] (Jul-95)				*Post-harvest* [c] (Nov-95)			
Nov-94	<-2 WAZ	≥-2 WAZ	Total	Mar-95	<-2 WAZ	≥-2 WAZ	Total	Jul-95	<-2 WAZ	≥-2 WAZ	Total
<-2 WAZ	16.4	9.1	25.5	<-2 WAZ	12.7	9.1	21.8	<-2 WAZ	14.5	0.0	14.5
≥-2 WAZ	5.5	69.1	74.5	≥-2 WAZ	1.8	76.4	78.2	≥-2 WAZ	7.3	78.2	85.5
Total	21.8	78.2	100.0		14.5	85.5	100.0		21.8	78.2	100.0

Table 6.9.14: *Change in seasonal prevalence rates of stunting (<-2 WAZ) for the pre-school population* *a.* χ^2=0.13, n.s. *b.* χ^2=0.83, n.s. *c.* χ^2=2.25, n.s.

The change in Seasonal Prevalence Rates in Stunting amongst Primary school-aged Population											
***Pre-harvest* [a] (Mar-95)**				***Harvest* [b] (Jul-95)**				***Post-harvest* [c] (Nov-95)**			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	9.6	0.0	9.6	<-2 HAZ	13.7	4.1	17.8	<-2 HAZ	13.7	0.0	13.7
≥-2 HAZ	8.2	82.2	90.4	≥-2 HAZ	0.0	82.2	82.2	≥-2 HAZ	0.0	86.3	86.3
Total	17.8	82.2	100.0		13.7	86.3	100.0		13.7	86.3	100.0

Table 6.9.15: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the primary school-aged population (n=73)*

a. χ^2=4.17, *p*=0.031; *b.* χ^2=1.3, n.s. c.χ^2=0.0 n.s.

The change in Seasonal Prevalence Rates in Thinness (<-2 BMIZ) amongst Primary school-aged Population											
***Pre-harvest* [a] (Mar-95)**				***Harvest* [b] (Jul-95)**				***Post-harvest* [c] (Nov-95)**			
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	8.2	9.6	17.8	<-2 BMIZ	4.1	5.5	9.6	<-2 BMIZ	4.1	0.0	4.1
≥-2 BMIZ	1.4	80.8	82.2	≥-2 BMIZ	0.0	90.4	90.4	≥-2 BMIZ	4.1	91.8	95.9
Total	9.6	90.4	100.0		4.1	95.9	100.0		8.2	91.8	100.0

Table 6.9.16: *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the primary school-aged population (n=73)*

a. χ^2=3.13 n.s. *b.* χ^2=2.25, n.s. c.χ^2=0.67, n.s.

The change in Seasonal Prevalence Rates in Wasting (<-2 WHZ) amongst Primary school-aged Population											
***Pre-harvest* [a] (Mar-95)**				***Harvest* [b] (Jul-95)**				***Post-harvest* [c] (Nov-95)**			
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Mar-95	<-2 WHZ	≥-2 WHZ	Total	Jul-95	<-2 WHZ	≥-2 WHZ	Total
<-2 WHZ	1.4	4.3	5.7	<-2 WHZ	0.0	2.9	2.9	<-2 WHZ	0.0	0.0	0.0
≥-2 WHZ	1.4	92.9	94.3	≥-2 WHZ	0.0	97.1	97.1	≥-2 WHZ	2.9	97.1	100.0
Total	2.8	97.2	100.0		0.0	100.0	100.0		2.9	97.1	100.0

Table 6.9.17: *Change in seasonal prevalence rates of wasting (<-2 WHZ) for the primary school-aged population (n=70)*

a. χ^2=0.25, n.s. *b.* χ^2=0.0, n.s. *c.* χ^2=0.0, n.s.

The change in Seasonal Prevalence Rates in Underweight (<-2 WAZ) amongst Primary school-aged Population											
***Pre-harvest* [a] (Mar-95)**				***Harvest* [b] (Jul-95)**				***Post-harvest* [c] (Nov-95)**			
Nov-94	<-2 WAZ	≥-2 WAZ	Total	Mar-95	<-2 WAZ	≥-2 WAZ	Total	Jul-95	<-2 WAZ	≥-2 WAZ	Total
<-2 WAZ	9.6	5.5	15.1	<-2 WAZ	5.5	4.1	9.6	<-2 WAZ	6.8	0.0	6.8
≥-2 WAZ	0.0	84.9	84.9	≥-2 WAZ	1.4	89.0	90.4	≥-2 WAZ	4.1	89.0	93.2
Total	9.6	90.4	100.0		6.8	93.2	100.0		11.0	89.0	100.0

Table 6.9.18: *Change in seasonal prevalence rates of underweight (<-2 WAZ) for the primary school-aged Pop. a.* χ^2=2.25, n.s. *b.* χ^2=0.25, n.s. *c.* χ^2=1.33, n.s.

The change in Seasonal Prevalence Rates in Stunting amongst Adolescent Population											
Pre-harvest [a]				***Harvest*** [b]				***Post-harvest*** [c]			
Mar-95				Jul-95				Nov-95			
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Mar-95	<-2 HAZ	≥-2 HAZ	Total	Jul-95	<-2 HAZ	≥-2 HAZ	Total
<-2 HAZ	23.3	1.7	25.0	<-2 HAZ	26.7	1.7	28.3	<-2 HAZ	25.0	3.3	28.3
≥-2 HAZ	5.0	70.0	75.0	≥-2 HAZ	1.7	70.0	71.7	≥-2 HAZ	3.3	68.3	71.7
Total	28.3	71.7	100.0		28.3	71.7	100.0		28.3	71.7	100.0

Table 6.9.19: *Change in seasonal prevalence rates of stunting (<-2 HAZ) for the adolescent population (n=60)*

a. χ^2=0.25, n.s.; *b.* χ^2=0 , n.s. c.χ^2=0, n.s.

The change in Seasonal Prevalence Rates in Thinness amongst Adolescent Population											
Pre-harvest [a]				***Harvest*** [b]				***Post-harvest*** [c]			
Mar-95				Jul-95				Nov-95			
Nov-94	<-2 BMIZ	≥-2 BMIZ	Total	Mar-95	<-2 BMIZ	≥-2 BMIZ	Total	Jul-95	<-2 BMIZ	≥-2 BMIZ	Total
<-2 BMIZ	11.7	3.3	15.0	<-2 BMIZ	11.7	1.7	13.3	<-2 BMIZ	8.3	3.3	11.7
≥-2 BMIZ	1.7	83.3	85.0	≥-2 BMIZ	0.0	86.7	86.7	≥-2 BMIZ	5.0	83.3	88.3
Total	13.3	86.7	100.0		11.7	88.3	100.0		13.3	86.7	100.0

Table 6.9.20: *Change in seasonal prevalence rates of thinness (<-2 BMIZ) for the adolescent population (n=60)*

a. χ^2=0.33; n.s. *b.* χ^2=0.0, n.s. c.χ^2=0.2, n.s.

The Annual change in Prevalence Rates in Stunting and Thinness amongst Pre-school Pop.							
Annual change stunting [a]				*Annual change in thinness* [b]			
	Nov-95				Nov-95		
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Nov-94	<-2 BMIZ	≥-2 BMIZ	Total
<-2 HAZ	20.0	7.3	27.3	<-2 BMIZ	5.0	5.0	10.0
≥-2 HAZ	3.6	69.1	72.7	≥-2 BMIZ	5.0	85.0	90.0
Total	23.6	76.4	100.0		10.0	90.0	0.0

Table 6.9.21: *Change in annual prevalence rates of stunting (<-2 HAZ) and thinness (<-2 BMIZ) for the pre-school population* *a.* χ^2=0.17, n.s. *b.* χ^2=0.0, n.s.;

The Annual change in Prevalence Rates in Wasting and Underweight amongst Pre-school Pop.							
Annual change wasting [a]				*Annual change in underweight* [b]			
	Nov-95				Nov-95		
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Nov-94	<-2 WAZ	≥-2 WAZ	Total
<-2 WHZ	0.0	3.6	3.6	<-2 WAZ	16.4	9.1	25.5
≥-2 WHZ	0.0	96.4	96.4	≥-2 WAZ	5.5	69.1	74.5
Total	0.0	100.0	100.0		21.8	78.2	100.0

Table 6.9.22: *Change in annual prevalence rates of wasting (<-2 WHZ) and underweight (<-2 WAZ) for the pre-school population* a. χ^2=0.0, n.s.; b. χ^2=1.13,n.s.;

The Annual change in Prevalence Rates of Stunting & Thinness in Primary school-aged Pop.							
Annual change stunting [a]				*Annual change in thinness* [b]			
	Nov-95				Nov-95		
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Nov-94	<-2 BMIZ	≥-2 BMIZ	Total
<-2 HAZ	9.6	0.0	9.6	<-2 BMIZ	8.2	9.6	17.8
≥-2 HAZ	4.1	86.3	90.4	≥-2 BMIZ	0.0	82.2	82.2
Total	13.7	86.3	100.0		8.2	91.8	100.0

Table 6.9.23: *Change in annual prevalence rates of stunting (<-2 HAZ) and thinness (<-2 BMIZ) for primary school population* *a.* χ^2=0.67, n.s.; *b.* χ^2=0.86, n.s.;

The Annual change in Prevalence Rates of Wasting & Underwht in Primary school-aged Pop.							
Annual change wasting [a]				*Annual change in underweight* [b]			
	Nov-95				Nov-95		
Nov-94	<-2 WHZ	≥-2 WHZ	Total	Nov-94	<-2 WAZ	≥-2 WAZ	Total
<-2 WHZ	2.9	2.9	5.7	<-2 WAZ	8.2	6.8	15.1
≥-2 WHZ	0.0	94.3	94.3	≥-2 WAZ	2.7	82.2	84.9
Total	2.9	97.1	100.0		11.0	89.0	100.0

Table 6.9.24: *Change in annual prevalence rates of wasting (<-2 WHZ) and underweight (<-2 WAZ for primary school population* a. χ^2=0.50, n.s.; *b.* χ^2=0.57, n.s.;

The Annual change in Prevalence Rates of Stunting & Thinness amongst Adolescent Pop.							
Annual change stunting [a]				*Annual change in thinness* [b]			
	Nov-95				Nov-95		
Nov-94	<-2 HAZ	≥-2 HAZ	Total	Nov-94	<-2 BMIZ	≥-2 BMIZ	Total
<-2 HAZ	23.3	1.7	25.0	<-2 BMIZ	10.0	5.0	15.0
≥-2 HAZ	5.0	97.7	75.0	≥-2 BMIZ	3.3	81.7	85.0
Total	28.3	71.7	100.0		13.3	86.7	100.0

Table 6.9.25: *Change in annual prevalence rates of stunting (<-2 HAZ) and thinness (<-2 BMIZ) for adolescents (n=60)* *a.* χ^2=0.25, n.s.; *b.*χ^2=0.2, n.s.;

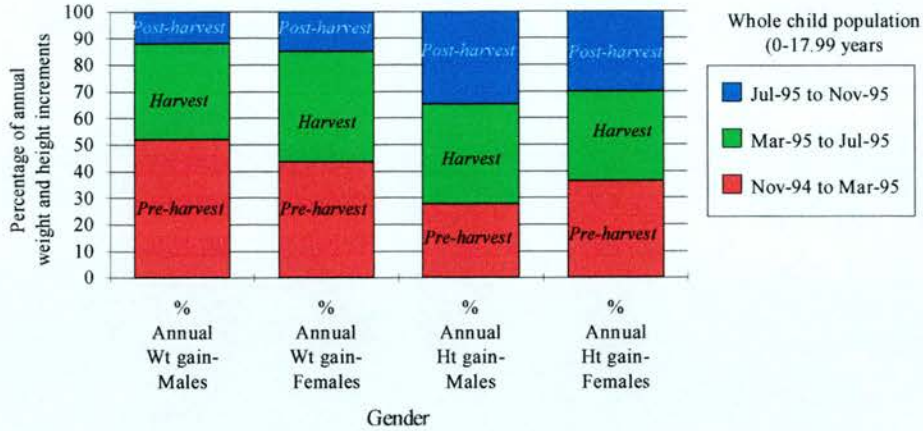

Figure 6.26: *Seasonal weight increments expressed as a percentage of total annual weight and height velocity for the whole population aged 0-17.99 years by gender (n=188)*

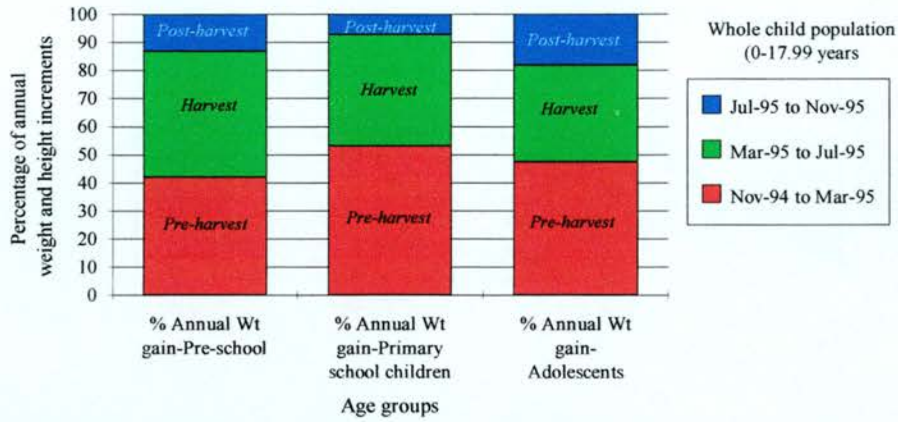

Figure 6.27: *Seasonal weight increments expressed as a percentage of total annual weight velocity for the whole population aged 0-17.99 years by age group (n=188)*

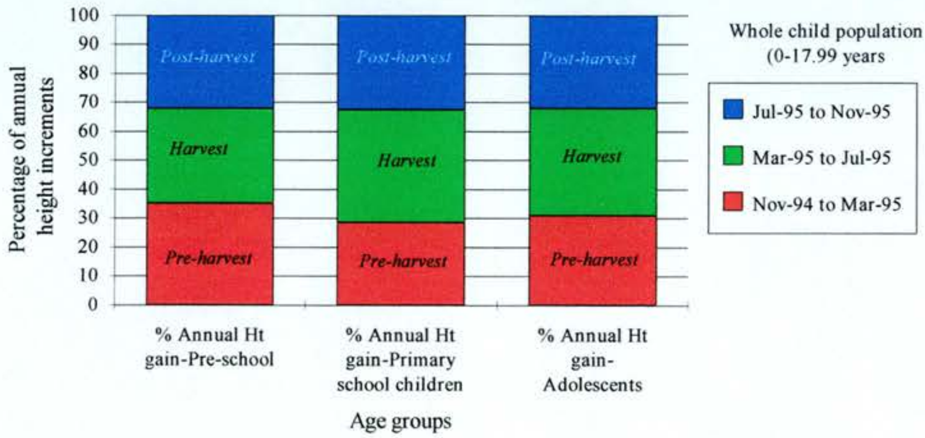

Figure 6.28: *Seasonal height increments expressed as a percentage of total annual height velocity for the whole population aged 0-17.99 years by age group (n=188)*

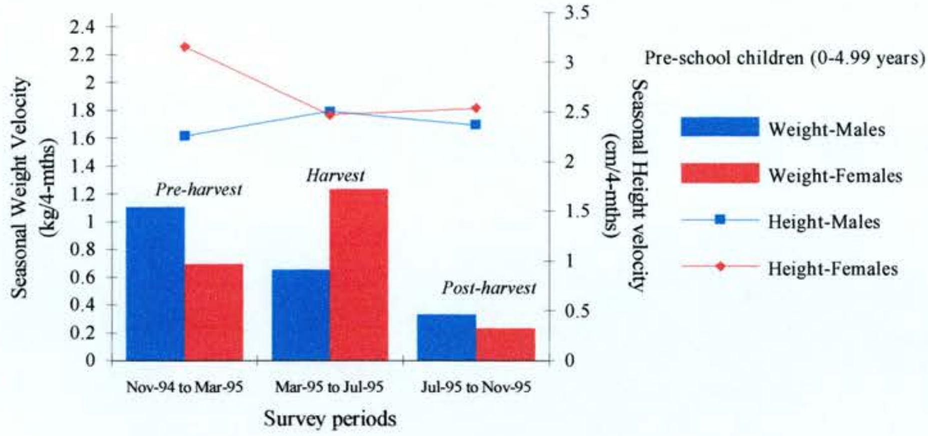

Figure 6.29: *Estimated mean 4-monthly weight (kg/4 months) and height velocity (cm/4months) by season for Pre-school children aged 0-4.99 years*

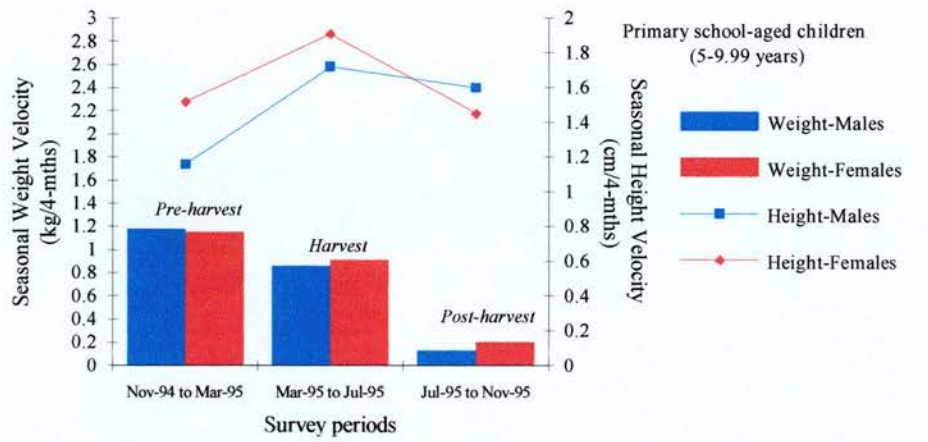

Figure 6.30: *Estimated mean 4-monthly weight (kg/4 months) and height velocity (cm/4months) by season for Primary-school children aged 5-9.99 years*

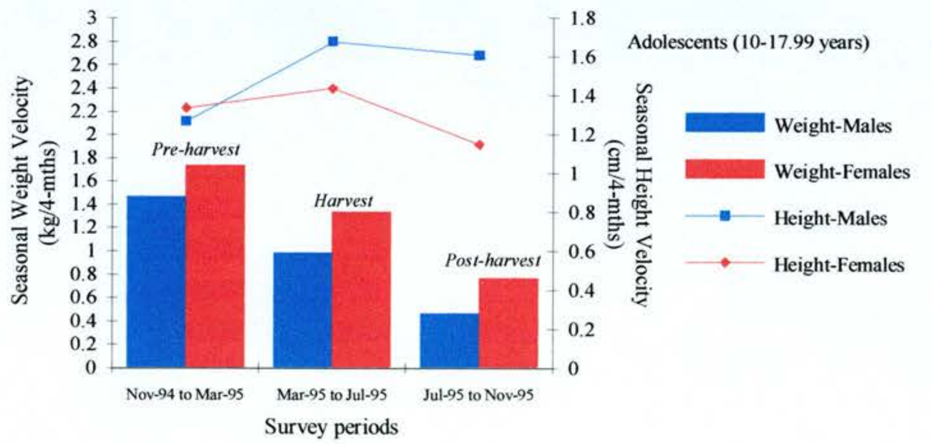

Figure 6.31: *Estimated mean 4-monthly weight (kg/4 months) and height velocity (cm/4months) by season for Adolescents aged 10-17.99 years*

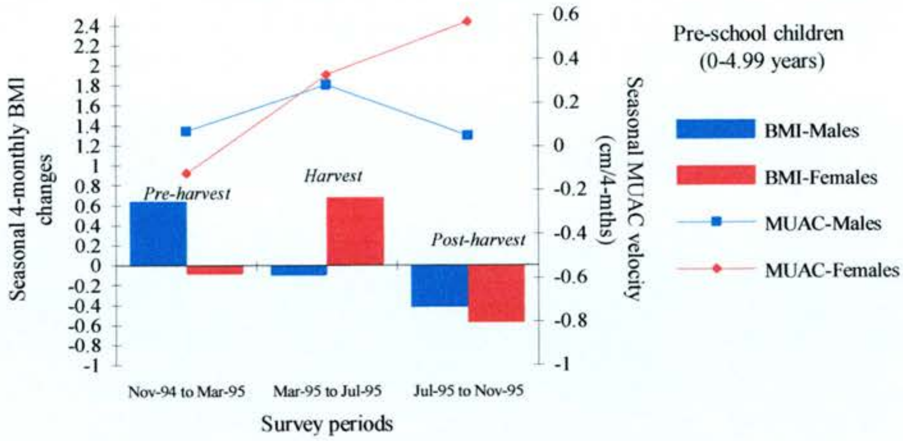

Figure 6.32: *Estimated mean 4-monthly MUAC velocity (cm/4months) and BMI change by season for Pre-school children aged 0-4.99 years*

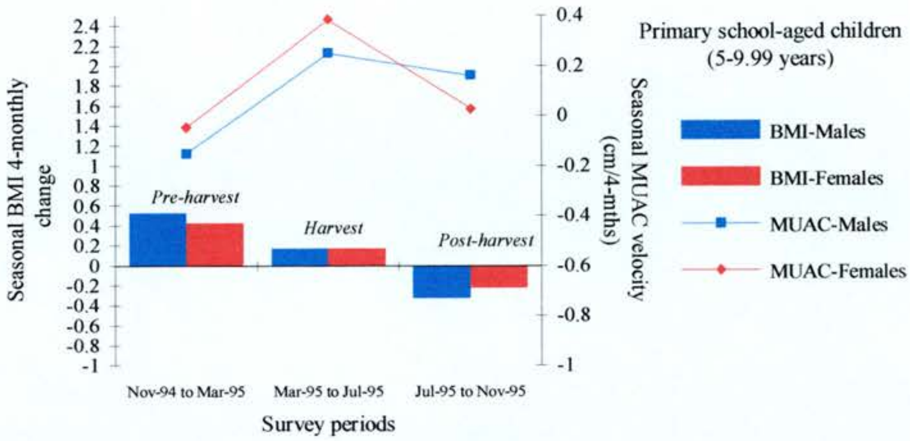

Figure 6.33: *Estimated mean 4-monthly MUAC velocity (cm/4months) and BMI change by season for Primary school-aged children aged 5-9.99 years*

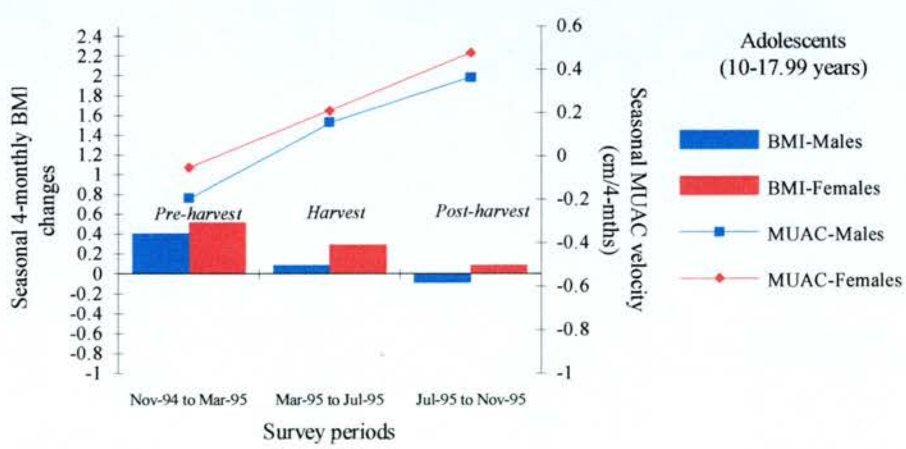

Figure 6.34: *Estimated mean 4-monthly MUAC velocity (cm/4months) and BMI change by season for Adolescents 10-17.99 years*

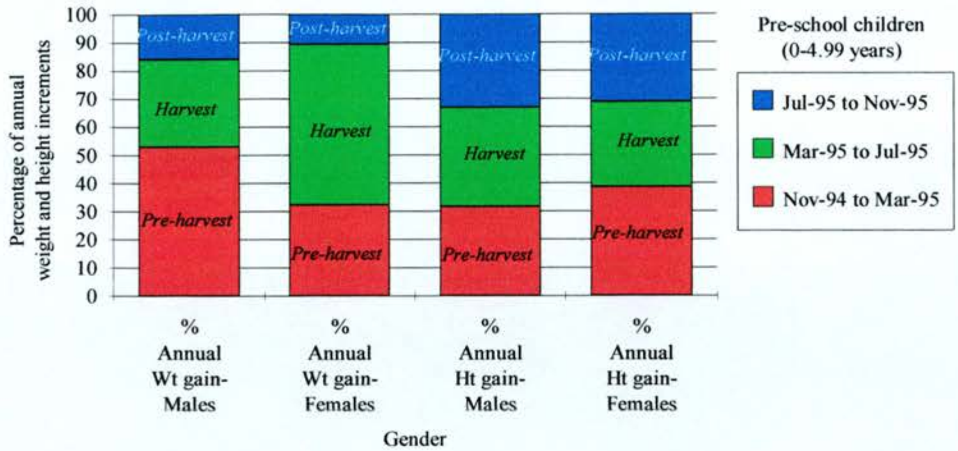

Figure 6.35: *Seasonal weight and height increments expressed as percentage of total annual weight and height velocity for pre-school children aged 0-4.99 years (n=55)*

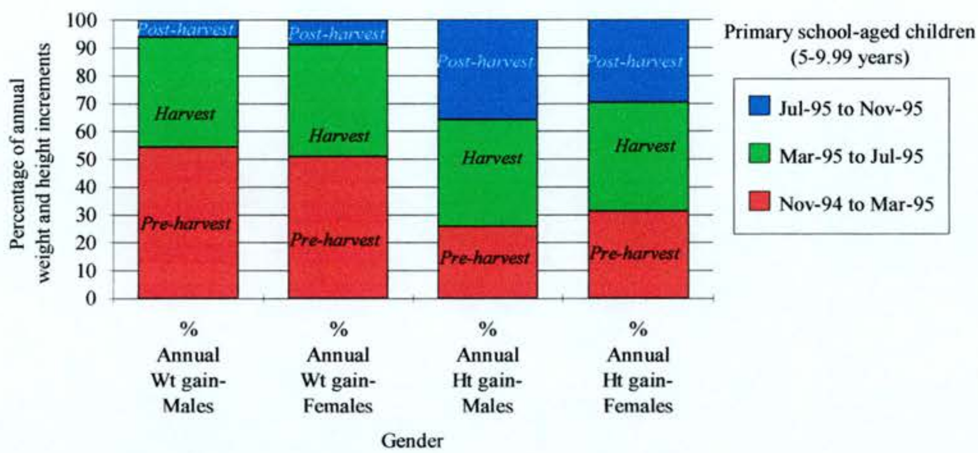

Figure 6.36: *Seasonal weight and height increments expressed as percentage of total annual weight and height velocity for primary school-aged population 5-9.99 years (n=73)*

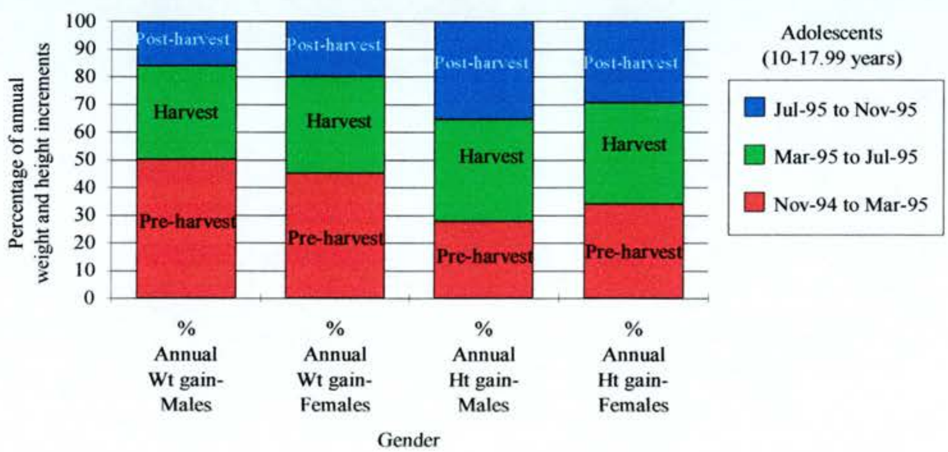

Figure 6.37: *Seasonal weight and height increments expressed as percentage of total annual weight and height velocity for adolescents 10-17.99 years (n=60)*

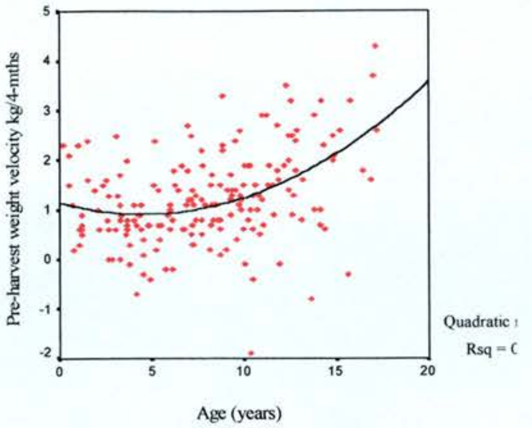

Figure 6.38: Quadratic regression age and pre-harvest weight velocity for whole child population (0-17.99 years)

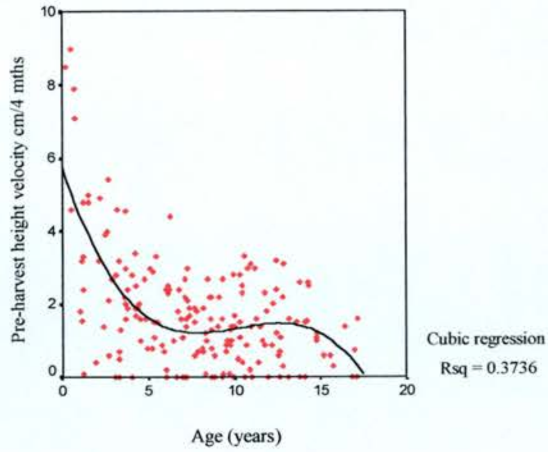

Figure 6.41: Cubic regression age and pre-harvest height velocity for whole child population (0-17.99)

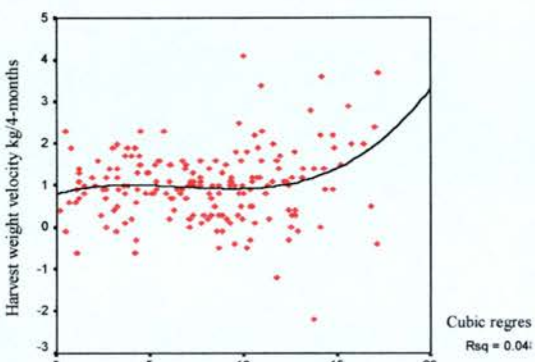

Figure 6.39: Quadratic regression between age and harvest weight velocity for whole child population (0-17.99 years)

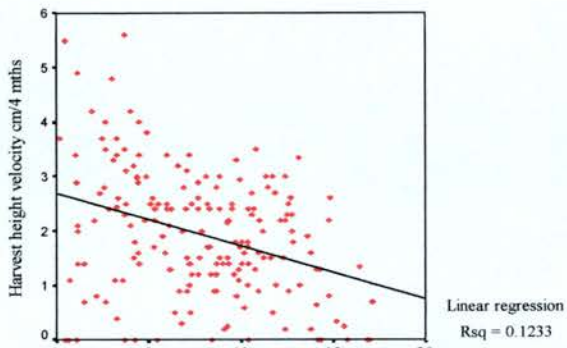

Figure 6.42: Linear regression between age and harvest height velocity for whole child population (0-17.99 years)

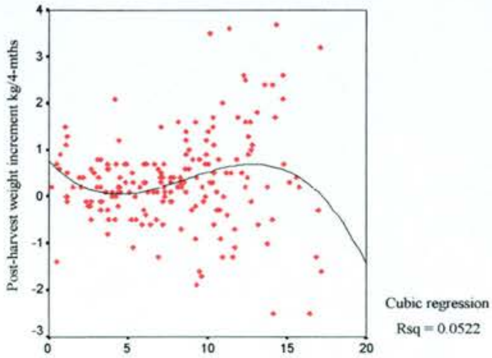

Figure 6..40 Quadratic regression age and post-harvest weight velocity for whole child population (0-17.99 years)

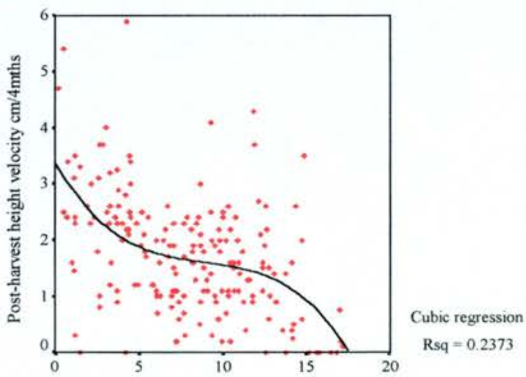

Figure 6.43 Cubic regression age and post-harvest height velocity for whole child population (0-17.99 years)

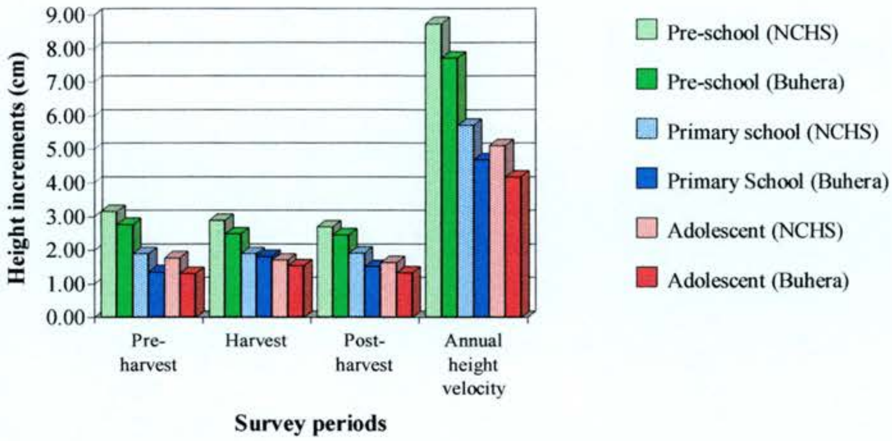

Figure 6.44: *Seasonal and annual height velocity compared to derived increments from the NCHS median by age group*

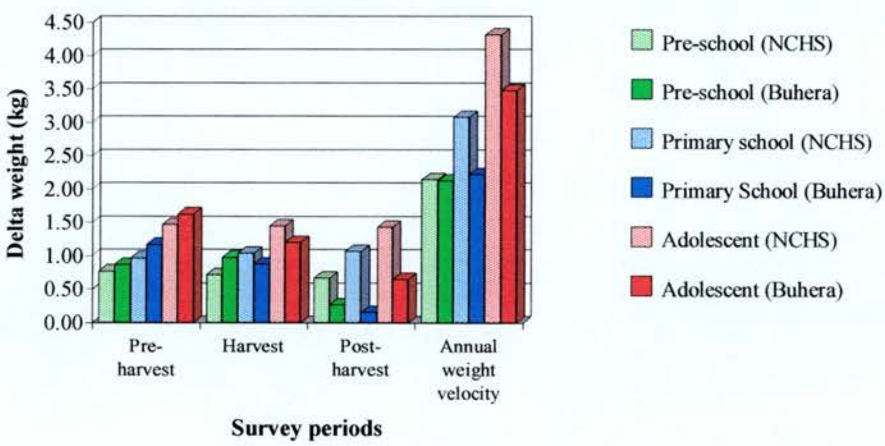

Figure 6.45: *Seasonal and annual weight velocity compared to derived increments from the NCHS median by age group*

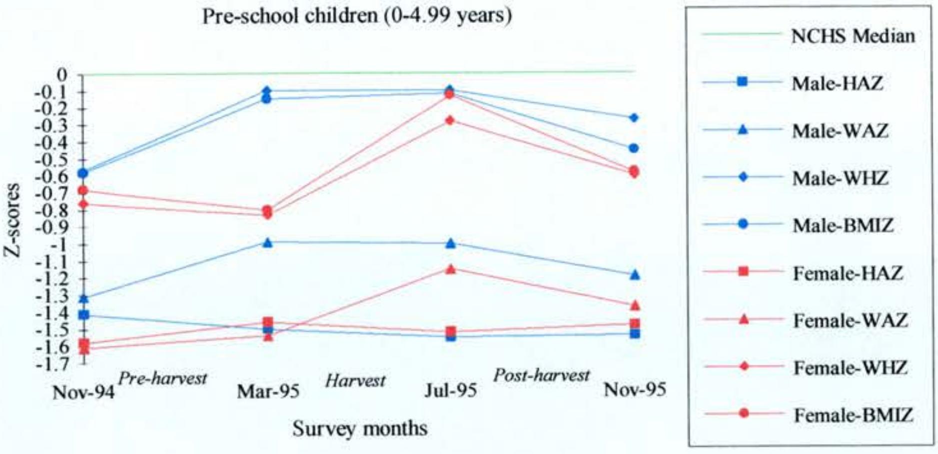

Figure 6.46: *Estimated mean Height for age (HAZ), BMI for age (BMIZ), Weight for height (WHZ), Weight for age (WAZ) Z-scores by gender and season for pre-school children aged 0-4.99 years controlling for age*

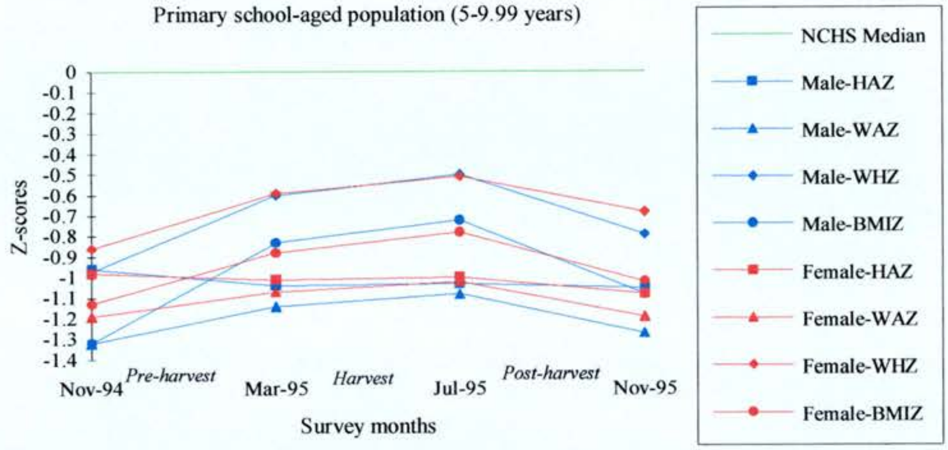

Figure 6.47: *Estimated mean Height for age (HAZ), BMI for age (BMIZ), Weight for height (WHZ), Weight for age (WAZ) Z-scores by gender and season for primary-school children aged 5-9.99 years controlling for age*

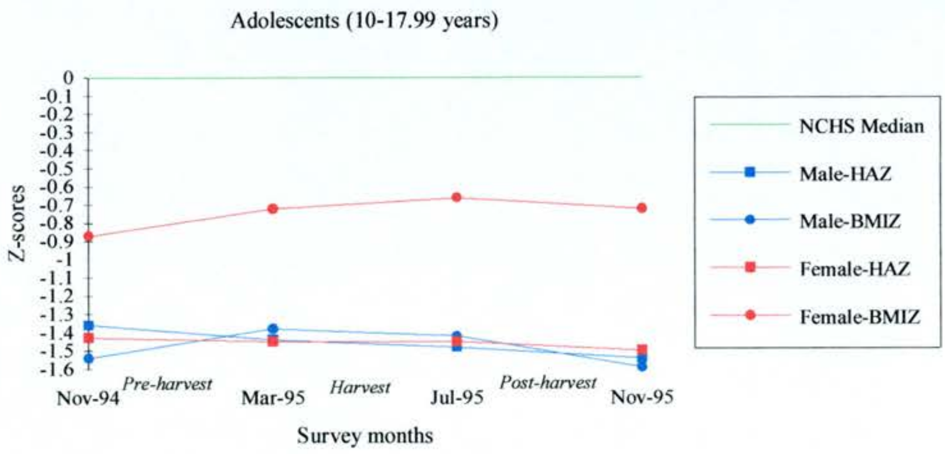

Figure 6.48: *Estimated Height for age (HAZ) and BMI for age (BMIZ) Z-scores by gender and season for adolescents (10-17.99 years) controlling for age*